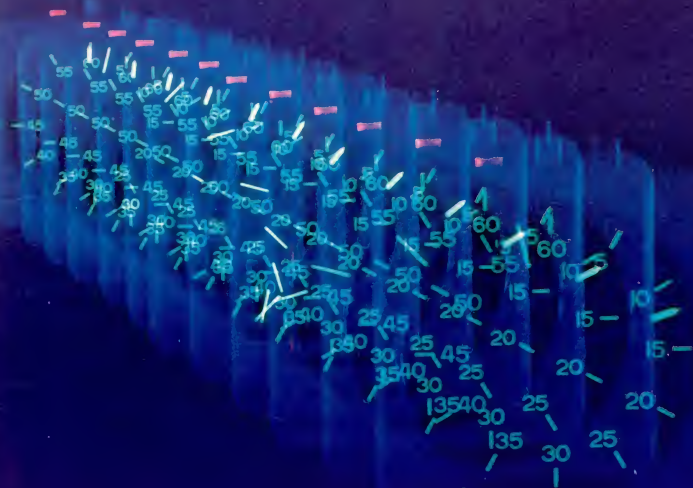


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The making of star wars
All things bright and poisonous



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This week's cover by John Hilliard. Increase the disorder in the Universe by 3×10^{24} units, starting on p 46

newscientist



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Superpoisons from plants

Satellite TV cuts out the scroungers

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New Scientist is published weekly by IPC Magazines Ltd. Registered at the Post Office as a newspaper and printed in England. 2nd class postage paid at Jamaica NY 11431. USA POSTMASTER: Send address changes to New Scientist, Publications Expediting Inc, 200 Meacham Avenue, Elmont, NY 11003. Airfreight and mailing in the USA by Publications Expediting Inc, 200 Meacham Avenue, Elmont, NY 11003.
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For an application form please write to or telephone quoting reference VN582 Recruitment Office, Personnel Group, Rutherford Appleton Laboratory, Science and Engineering Research Council, Chilton, Didcot Oxon OX11 0QX. Tel: (0235) 445435.

Applications must be returned by: 31st July 1987



Rutherford Appleton Laboratory

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Starting salary £8185—point 1 of the range 1B.

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There are no special application forms. Written applications with full cv, including the names of three referees, should be sent to the University Secretary, University of Stirling, Stirling FK9 4LA. Tel 0788 73171, Ext 2314, by 22 July 1987, from whom further particulars are available.



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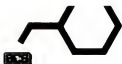
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64-87

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Requests for further particulars should be addressed to Dr J Alwen, MRC Headquarters Office, 20 Park Crescent, London W1N 4AL, telephone 01-636 5422 ext. 348, within four weeks of the date of the appearance of this advertisement.

Microbiologist

Cheshire

An opportunity now exists within ICI's Genetic & Experimental Toxicology Unit, Safety of Medicines Department for a graduate, to join a team undertaking mutagenicity assays on ICI development medicines for regulatory purposes. The work will involve the operation of bacterial mutation assays, the modification of these assays and their validation using known mutagens/carcinogens for specific compound related problems. Applicants must have a knowledge of microbiological techniques and at least two years experience of regulatory bacterial mutation assays. An understanding of genetics would be desirable.

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Applications including a detailed cv., should be addressed to:-



The Personnel Officer, (Ref GET),
Imperial Chemical Industries PLC,
Pharmaceuticals Division, Mereside,
Alderley Park, Macclesfield, Cheshire SK10 4TG.

Closing date for applications is 30 July 1987

ICI is an equal opportunities employer.

MACAULAY LAND USE RESEARCH INSTITUTE

Nutritional Biochemist (Higher Scientific Officer) (Ref No MB/1)

Applications are invited from a nutritional biochemist to undertake research on the energy expenditure of ruminants as influenced by their behaviour in grazing sown and indigenous swards and in the context of farm/forestry systems. The appointee will be based initially at the Institute's site near Edinburgh.

The appointment will be in the grade of Higher Scientific Officer on a salary scale of £8733-£11785. Applicants should have a first or upper second class honours degree in the Biological Sciences with at least two years post-qualifying relevant research experience which may be a course of research and study leading to a PhD degree.

Animal Scientist (Higher Scientific Officer) (Ref No MB/2)

Applications are invited from a graduate in Agricultural or Biological Sciences with at least two years post-graduate research experience in Animal Science to conduct research on aspects of ewe size, lactation and reproduction and on pre- and post-weaning lamb growth in relation to resource use in the upland and marginal hillside of Britain. The appointee will be based initially at the Institute's site near Edinburgh.

The appointment will be in the grade of Higher Scientific Officer on a salary scale of £8733-£11785. Applicants should have a first or upper second class honours degree in the Biological Sciences with at least two years post-qualifying relevant research experience which may be a course of research and study leading to a PhD degree.

Grazing Ecologist (Senior Scientific Officer/ Higher Scientific Officer) (Ref No MB/3)

Applications are invited from a graduate in agricultural or biological sciences with at least two years post-graduate research experience in some aspect of herbivore grazing to undertake a programme of research on the ethological aspects of diet selection and intake by grazing ruminants in hill and upland environments. The appointee will be based initially at the Institute's site near Edinburgh.

The appointment will be in the grade of either Senior Scientific Officer on a salary scale of £10970-£14299 or Higher Scientific Officer on a salary scale of £8733-£11785. Applicants should have a first or upper second class honours degree in the Agricultural or Biological Sciences with at least two years post-qualifying relevant research experience for SSO which may be a course of research and study leading to a PhD degree.

The positions are superannuable and the Institute is an equal opportunities employer.

Further details and application forms can be obtained from the Site Secretary, Macaulay Land Use Research Institute, Bush Estate, Penicuik, Midlothian EH26 0PY, to whom they should be returned no later than 31 July 1987. Please quote the appropriate reference number.

Please send
Replies
to Box No
Advertisements
c/o New Scientist

Career Development Opportunities in New Food Products Reading

Tate & Lyle PLC is a successful international company with interests in food, agriculture and industrial products and a turnover of £1.6 billion. Based at Reading, Group R & D serves Tate & Lyle companies worldwide by improving existing processes and developing new products.

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Reporting to the Product Development Manager, the job holders will be responsible for the development of our expanding range of novel products and will have a key role in championing retail and industrial opportunities. An important aspect will be liaising with suppliers and manufacturing companies, both within and outside the Group and with research organisations.

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If you have a few years appropriate experience and are looking for career development, these vacancies represent an ideal opportunity to take real responsibility and broaden your experience at the same time.

An attractive remuneration package is offered, including non-contributory pension scheme and free lunches.

Please apply with C.V. to: Personnel Manager, Tate & Lyle Group R & D, P.O. Box 68, Whiteknights, Reading, Berks., RG6 2BX. Telephone: (0734) 861361.

Sensory Analysis

Reporting to the Sensory Analysis Manager, the jobholder will be accountable for the design and implementation of a wide range of sensory programmes. He or she will organise sensory work carried out by a consumer panel and several expert panels.

Preferably in your mid to late twenties you will have a degree/HNC in an appropriate subject (eg. Food Science or Psychology) plus a minimum of 2.5 years relevant experience. You must have had broad based sensory analysis experience including QDA and be familiar with the latest available computer hardware/software. It is essential to be able to communicate effectively at all levels.

Tate & Lyle

Society for General Microbiology Administrative Assistant (Finance)

The Society for General Microbiology requires a new or recent graduate to provide administrative assistance to the Executive Secretary and Honorary Treasurer in financial aspects of the Society's affairs. Previous financial training or expertise are not necessarily required, for appropriate training will be given. More important are numeracy, general intelligence and initiative.

Salary on University Administrative Scale, starting at Grade 1 (£8185-£11015, rising to £8675-£11690 from March 1988), at a point according to age, qualifications and experience, and proceeding, subject to satisfactory progress, to Grade 2.

Further details from: The Executive Secretary, Society for General Microbiology, 62 London Road, Reading RG1 5AS.



Experienced Analyst

required for rapidly expanding environmental laboratory.

The vacancy exists for a qualified Asbestos Analyst with experience in Asbestos Air Monitoring and Bulk Sample Identification. The applicant must be well spoken and highly presentable with an ability to communicate at all levels. A competitive, remuneration package will be offered to the right person.

Please Phone: 01-350 0140.

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We are a high technology health care company concerned with the manufacture of novel diagnostic products. Due to our continued expansion we wish to recruit additional

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to be responsible for the control and inspection of diagnostic medical devices.

Qualified to HNC level in Chemistry/Biochemistry or equivalent and ideally with some laboratory experience in the diagnostic, pharmaceutical or a related industry. However, this is not an essential pre-requisite as training will be given to the right type of persons.

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The initial salary will be in the range £7000-£9000 per annum and will be negotiated depending on individual age and experience. We also offer a full benefits package including relocation expenses where appropriate. Company pension fund and executive stock options.

If you are interested in these positions, please forward a full curriculum vitae together with the names of two referees to:

Dr David Carson
Genetics International (UK) Inc
38 Nuffield Way
Abingdon
Oxon OX14 1RL

Please note that persons who have previously applied for these posts need not re-submit their applications.

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RESEARCH & DEVELOPMENT

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Regulatory Authorities worldwide require that all Safety Evaluation and Clinical work performed in the development of pharmaceuticals is conducted to high standards of integrity and quality. It is Fisons' policy to work to these standards and it is the responsibility of Research and Development Quality Assurance to monitor this work, on a worldwide basis, to ensure that we comply.

Due to an increase in the duties of Research & Development Quality Assurance to cover all clinical studies, we have a vacancy for an additional Inspector. The person appointed will be part of a team with responsibility for the monitoring of all aspects of experimental procedures covered by the regulations.

The job will be based at the Research and Development Laboratories in Loughborough, but travel to other locations will be necessary as required.

Candidates should possess an appropriate degree in a chemical or biological discipline with several years experience in a research environment. Qualifications will include meticulous attention to detail, recognition of the importance of defined standards of work and ability to deal tactfully and patiently with people to ensure standards are observed.

We offer excellent conditions of employment which include a profit sharing bonus, flexitime, 25 days annual holiday plus generous relocation assistance, where applicable, to this attractive and inexpensive part of the country.

Interested applicants should apply for an application form to: Mrs. Olive Jones — Personnel Officer, Fisons plc — Pharmaceutical Division, Bakewell Road, Loughborough, Leicestershire LE11 0RH.

FISONS

Pharmaceuticals

Please quote reference number 398/ins on all correspondence.

AFRC INSTITUTE FOR GRASSLAND AND ANIMAL PRODUCTION

Hurley, Maidenhead, Berks SL6 5LR

TEMPORARY SCIENTIFIC OFFICER

required for two years to join a team working on the problems of environmental pollution by wastes from livestock farming. The person will be involved in experiments aimed at developing methods for controlling the offensive odours that are a common source of complaint when manures from housed pigs and cattle are spread on farm land. In particular, this will involve the use of quantitative techniques for collecting samples of odorous air from the field and assessment by olfactometry and other methods. Qualifications: Degree in chemistry, biochemistry, environmental science, or other relevant discipline. Experience, training or interest in computing and/or electronics would be an advantage.

Starting Salary: £6973-£7731 according to qualifications and experience.

Application forms from the Personnel Officer quoting 1/J/88. An Equal Opportunities Employer.

ST GEORGE'S HOSPITAL MEDICAL SCHOOL

(University of London)

RESEARCH TECHNICIAN GRADE 5 CELL BIOLOGY/ BIOCHEMISTRY

A vacancy exists for a research technician to join a small group investigating the biology of normal and malignant breast cells. The successful candidate will work on the effects of oncogenic transformation on the development of cell polarity. The work involves transfection procedures and the development of monoclonal antibodies to proteins present in specific domains of the plasma membrane of breast cells. Training is available in these techniques. This work is funded by the Cancer Research Campaign for two years. The starting salary will be up to £7938 depending on experience and qualifications, plus £840 London Allowance pa.

Full cv with the names and addresses of two referees should be sent to Dr M. J. Warburton, Department of Histopathology, St George's Hospital Medical School, Cranmer Terrace, London SW17 0RE to whom informal enquiries may be made on Tel 01-672 1255, Ext 4755. Please quote reference 95/87.

UNIVERSITY OF DURHAM POSTDOCTORAL RESEARCH ASSISTANT IN SEMICONDUCTOR THEORY

Applications are invited for a Senior Research Assistantship tenable for two-and-a-half years from 1 September, 1987, or as soon as possible thereafter to join an active research group with an established reputation in the physics of semiconductor, for work on the theory of Transport in Strained Layer Semiconductor Superlattices under the direction of Dr Brand and Dr Abram of the School of Engineering and Applied Science.

Experience of semiconductor theory and computational work would be useful but research experience in any branch of theoretical solid state physics will be welcomed. The work is part of SERC's coordinated national programme on Low Dimensional Structures and will emphasise the SiGe system.

Initial salary £9865-£10 440 pa on Grade 1A with superannuation. Applications (three copies) naming three referees should be sent by 17 July, 1987 (quoting Ref SAJ) to the Registrar, Science Laboratories, South Road, Durham DH1 3LE from whom further particulars are available or by telephoning 091-374 2263.

NATURE CONSERVANCY COUNCIL

SCIENTISTS—TEMPORARY POSTS

The NCC has vacancies for scientists on two current projects. GEOLOGISTS—Earth Science Division Ref HE2-36-82

Two Scientific Officers (SO) are required to work on renatification of ecological and geomorphological SSSIs. Duties include definition of site boundaries, identification of activities potentially damaging to the sites' interest and the compilation of notification packages for despatch to NCC's regional staff.

Term and Base—up to September 1990, based in Peterborough.

Qualifications—Applicants must have a degree in geology or geography; some knowledge of the site safeguard provisions of the Wildlife and Countryside Act 1981; ability to communicate with landowners and occupiers; experience in practical site management.

BUTTERFLY ECOLOGIST—Chief Scientist Directorate Ref: HE2-36-83

A Higher Scientific Officer (HSO) is required to draw up management recommendations for important butterfly sites in Britain and to disseminate information on the habitat requirements of butterflies to NCC staff and other conservation organisations.

Term and Base—18 months starting 1 October, 1987, based in Peterborough.

Qualifications—Applicants must have a degree in a relevant scientific subject and must have a minimum of two years relevant post graduate experience. A good publishing record and ability to communicate well are required; knowledge of ecological needs of a range of rarer British butterflies and management techniques for their habitats expected.

Salary SO £6711-£9225, HSO £8405-£11 323 depending upon qualifications and experience.

Application forms and further details available from Personnel 1, Nature Conservancy Council, Northminster House, Peterborough PE1 1UA. Please quote Ref to show. Closing date for completed applications is 30 July, 1987.

NCC is an Equal Opportunities Employer.

UNIVERSITY OF READING Department of Physiology and Biochemistry

POSTDOCTORAL RESEARCH FELLOW

required for a fixed period of one year from 1 October 1987, to work on a research project concerning the neurophysiology of neonatal breathing and behaviour. Applicants should have some experience of electrophysiological recording or of anatomical tracing techniques applied to the mammalian central nervous system. Starting salary up to £11 460 pa. Apply for further particulars and Application Form to Personnel Officer, University of Reading, Whiteknights, PO Box 217, Reading RG6 2AH. Closing date 22 July, 1987. Please quote Ref R37.

FOOD MICROBIOLOGIST

CAMBRIDGE

Spillers Foods Limited, a member of the Dalgety group of companies, has a vacancy for a Food Microbiologist. The position has arisen through the need for an increased level of technical activity in support of continued business growth.

The successful candidate will join the team based at the company's Central R & D laboratories in Cambridge.

He/she will have an honours degree (or equivalent) with microbiology as a main component and will already have had several years experience in industry.

We offer a competitive salary together with the usual large company benefits.

Please write or telephone for an application form to:-

Heather Stewart,
SPILLERS FOODS LIMITED
New Malden House, 1 Blagdon Road,
New Malden, Surrey KT3 4TB.
Tel: 01-949 6100

Spillers Foods

ANALYTICAL CHEMIST

£11 000-£15 000

The Head Office of Schweppe International Limited, based in North London, provides financial, commercial and technical support to bottlers in more than 50 countries worldwide.

A vacancy has arisen for an Analytical Chemist to join our technical group. Managing a team of up to three, you will use modern instrumental equipment eg hplc, glc and spectroscopy as well as classical analysis for the examination of soft drinks and their ingredients. You will become involved in troubleshooting activities and, in time, also be able to offer skilled technical advice to manufacturing operations; some overseas travel may be required.

You will have a degree or equivalent in Chemistry with 2-3 years experience of relevant instrumental analytical techniques. You will also possess excellent communication skills and have sound administrative ability.

A first class remuneration package and excellent career prospects are available to the successful applicant.

To apply, please write with full career details to:

The Personnel Officer
Schweppe International Limited
Schweppe House
105 Brook Road
Dollis Hill
London NW2 7DS

Cadbury Schweppe



UNIVERSITY OF SOUTHAMPTON

Lymphoma Research Unit
TWO POSTDOCTORAL
SCIENTISTS

Two Postdoctoral Scientists are required to participate in a long-term programme studying the killing of neoplastic lymphocytes by antibody, with subsidiary projects on lymphocytic surfaces and antibody effector mechanisms. There will be an opportunity to participate in a current clinical trial of the treatment of lymphoma with antibody derivatives. Salary on University 1A scale for research staff (£9005-£14 925 pa). Appointment for three years with possibility of extension. Enquiries to Prof G. T. Stevenson. Applications to include cv and the names and addresses of two referees, to Prof G. T. Stevenson, Lymphoma Research Unit, Tenovus Laboratory, General Hospital, Southampton SO9 4XY as soon as possible.

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September onwards

**BRIGHT YOUNG DOMESTIC
ASSISTANTS**

required for kitchen and housework, to join enthusiastic team at an outdoor centre of Lake Windermere.

Full board provided. Good working conditions. No experience required.

Please write to Mr Gerry Heale, Brathay Hall Trust, Brathay Hall, Ambleside, Cumbria LA22 0HP.

Associated Nuclear Services

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Epsom

Up to £13 000 pa

ASSOCIATED NUCLEAR SERVICES, a firm of consulting engineers and scientists, carrying out a variety of projects for industry, government departments and international agencies, has vacancies for biologists and environmental scientists to work in the Environmental Safety Department.

The work is aimed at improving and developing the methods and data on which assessments are made of the radiological impact of releases from nuclear installations and the disposal of radioactive wastes. It includes literature review, development and application of computer models, experimental programmes and field measurements. Work is also undertaken on the behaviour and effects of hazardous chemicals.

Applications are invited from graduate or postgraduate biologists and environmental scientists. Some experience in mathematical modelling and/or computer programming would be an advantage. Appointments would be at the scientist or senior scientist grade depending on experience and qualifications.

ANS works a 36 hour week, has 5 weeks annual holiday plus statutory holidays, a contributory pension and life assurance plan, and non-contributory accident and permanent disability insurance cover is provided.

Application forms from Mrs G. Dorrington, 60 East Street, Epsom, Surrey. Tel Epsom (03727) 40531. Ref. 87/10.

ANS

Associated Nuclear Services

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MLSO (BASIC GRADE/
JUNIOR B)

£8119-£9704 pa inc.

Required in the department of Haematology to assist in developing a regional screening program for haemoglobinopathies.

This post is on a fixed term contract of nine months and would suit an experienced person with an interest in research.

Informal enquiries to Joan Henthorne, Senior Chief on 01-965 5733, Ext 2323.

Written details from Lorraine Haslie, Unit Personnel, Central Middlesex Hospital, Acton Lane, London NW10 1YA, Ext 2480. Central Middlesex Hospital working for equal opportunities.

TECHNICAL PUBLICATIONS

MANAGER

Mid Sussex: Salary negotiable

Kumbe Instruments is an expanding manufacturer of laboratory robots.

We require a Technical Publications Specialist to take charge of all technical writing and in-house publications.

Applicants should have a scientific background and an interest in technical writing. Experience of laboratory work and desktop publishing systems would be an advantage.

Please telephone us on 04446 47632 for further details and an application form.

Quality Assurance and Analytical Services Manager

John & E Sturge, a highly reputable manufacturer of citric acid, enzymes and other biotechnology products for the food, pharmaceutical, drinks and diagnostic industries and part of the RTZ Chemicals Group, now seek to fill this key position based at their Head Office in Selby, North Yorkshire.

The person appointed will be responsible to the Works Director for the efficient operation of the Quality Control and Analytical Services Department employing some 20 qualified and non-qualified staff. Responsibilities will involve provision of a QC service for all the Company's products with a current value in excess of £20 million per annum and of an analytical service to the Production, Research and Development Departments.

The Company is fully committed to Quality Assurance principles. The successful applicant will be expected to co-ordinate and promote the continued introduction and subsequent maintenance of a site wide Quality Assurance regime within BS 5750 and will be directly responsible to the Managing Director for this activity. Ideally, applicants should have a good working knowledge and experience in this field.

The position offers a challenging opportunity to work in a vigorous and expanding biotechnology based Company. Suitable candidates are likely to be aged 30-40 and must be graduate chemists, preferably with a higher degree in analytical chemistry or other appropriate subject, with at least 5 years' experience of laboratory management.

Excellent terms and conditions of employment are offered, including social and welfare facilities, 25 days' annual holiday (plus statutory holidays) and a first rate pension and life assurance scheme.



Sturge Biochemicals

a member of
the RTZ Group

Please apply in writing with a brief CV to the Personnel Director, (Ref: JJJG), John & E Sturge Ltd, Denison Road, Selby, North Yorkshire YO8 8EF.

UNIVERSITY OF NEWCASTLE UPON TYNE

Department of Clinical
Biochemistry and Metabolic
Medicine

POSTDOCTORAL RESEARCH ASSOCIATE

Applications are invited for a Research Associate post in the Biosensor Research Group of the Department of Clinical Biochemistry and Metabolic Medicine. This is a SERC/ICI plc funded group working primarily on enzyme electrodes.

A person with a background in physical chemistry is required to fabricate and characterise enzyme electrodes. Although practical sensors are the aim of the group, the project would be of interest to anyone wanting to carry out studies of the medical use of biosensors.

The post is available immediately for up to three years. The starting salary will be determined according to age and experience but will not exceed £11 015 pa on the 1A scale (£9305-£14 825 pa).

Applicants should submit a cv and the names of three referees to Dr P. Vadgama, Department of Clinical Biochemistry, Medical School, Framlington Place, Newcastle upon Tyne NE2 4HH. (Tel 091 332511, Ext 3132) from whom further information may be obtained. Closing date 31 July, 1987.

Department of Civil Engineering

Transport Operations Research Group

RESEARCH STUDENTSHIP

"Detection and prevention of dangerous oscillatory traffic flow conditions on motorways"

Applications are invited for a doctoral studentship in the above field. The project is funded by the SERC under the Co-operative Awards in Science and Engineering scheme. The industrial partner for the project is Plessey Controls Ltd who will be supplementing the studentship.

Applicants should have a good Bachelor's or Master's degree in a numerate subject. For further particulars on this (or other) studentships please contact Dr M. G. H. Bell, Transport Operations Research Group, Claremont Tower, University of Newcastle upon Tyne. Applications for the above studentship, citing three references and including a cv should be received by Dr Bell before 21 August, 1987.

N. E. THAMES REGIONAL CYTOGENETICS UNIT

Queen Elizabeth Hospital
for Children

Hackney Road, London E2 8PS

BASIC GRADE

CYTOGENETICIST

required as soon as possible. Some experience an advantage but training will be provided in all aspects of clinical cytogenetics. A first or second class honours degree in the biological sciences with a genetic bias essential. Whitley Council salary and condition of service.

Applications by letter including a cv and the names of two referees to the director of the Unit by 17 July, 1987.

Molecular Biology PhD

Bacterial Expression of Foreign Genes

ICI is expanding its research activities in support of its Plant Protection and Seeds Businesses. We are looking for a talented and imaginative PhD level molecular biologist preferably with 1-2 years postdoctoral experience. The successful candidate will have good all round molecular biology skills and an interest in applying them to plant-related problems.

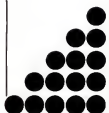
Working as part of an interdisciplinary team, you will initially focus on expression and manipulation of heterologous

genes in bacteria.

Located at our Jealott's Hill Research Station, you will receive a range of excellent company benefits including competitive salary and pension scheme. Please write with full c.v. including the names of two referees, and quoting ref IGB/TO to: Karen Grant, Recruitment Administrator, Jealott's Hill Research Station, Bracknell, Berkshire RG12 6EY.

Closing date: August 7th 1987.

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Vol 115 No 1568 9 July 1987

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On the seventh day, litigation

THE news from the US is that Darwinists have won another battle against the Christian fundamentalists. After two years of skirmishes in the courtroom, the fundamentalists have lost, in the Supreme Court, their claim that creationism should be taught alongside the theory of evolution in the classrooms of Louisiana.

Over the past decade, the fundamentalists, who believe the book of Genesis to be literally true, have mounted an assault on scientific curricula in schools unlike any seen since the 1920s.

The fact that these "creationists" have lost at every turn may put a little more strut in the step of scientists. Many scoffed at the fundamentalists' latest manoeuvre. This was the theory of "creation-science", which boasted scientific evidence for Genesis, the Noachian flood and the immutability of all creatures. The creationists claimed their "theory" was at least as solid as the admittedly fissured ground of evolution.

Had the Greeks built as wobbly a horse as the creation-scientists, they would never have made it past the gates of Troy. But the fact that the pious sought the trappings of science in this latest attempt to displace Darwin, holds a lesson or two worth noting.

For one, the creationists argued that evolution is "just a theory". Scientists, they argued, differ over evolution's mechanics and cannot demonstrate it in a laboratory. And many people, including two of the nine justices of the Supreme Court, bought that argument.

Somewhere along the line, many Ameri-

cans are misunderstanding the structure of science: that theory is a set of abstractions that tries to explain an agreed-upon set of facts. Even if some scientists disagree on the theory—indeed, even if the theory bows before the elegance of a new one—certain facts, in this case natural selection, remain.

But when the practitioners of faith begin to ape science, perhaps we should stop and think. The fact that the devout feel obliged to couch their doctrine in scientific jargon tells us as much about current views of science as it does about religion.

Are the lines between religion and science beginning to blur? One could argue that some in the White House, and probably the Kremlin too, view laser weapons in space as a technological *Deus ex machina* that will save us from our wickedness.

Dogma has worn the cassock. It can also slip into the laboratory smock. The philosopher of science, Thomas Kuhn, has pointed out that the conventional wisdoms of science—paradigms—rise and fall like empires. Light was material corpuses, according to Isaac Newton. Then in the 19th century Augustin Fresnel convinced physicists that light was transverse wave motion. By the 20th century, the theory evolved that light consists of quantum-mechanical entities—photons.

So too will the theory of evolution evolve. When we toast this victory over fraudulent science, we should also reflect that while evolution has been dug out of rock, no theory is written in stone. □

An open and shut case

THE LAWYERS' manoeuvres in the Open case (see p 17) should not be allowed to obscure the public importance of the issues involved. Indeed, there appears to be a direct conflict between the public interest and the private interests of the mainly elderly sufferers from the drug, a handful of whom have now been offered a settlement.

Past experience with drugs such as thalidomide and practolol suggests that out-of-court arrangements usually involve a clause in which the defendant denies liability but agrees to pay compensation.

This plays into the hands of the defendants, whose overriding interest is to avoid a judicial finding that they are guilty of negligence. Their incomparably greater resources enable them to achieve that end.

Pharmaceutical companies in general, and Eli Lilly in particular, set great store by the fact that they are "science based". So they are. The public interest requires that we establish whether the standards of science apply in their work. If a pharmaceutical company fails that test, then the public also needs to know why the public watchdog, the Committee on Safety of Medicines, failed to bark, and so also failed in its statutory duty.

However the issue of compensation in the Open case is resolved between the parties, one thing is now clear. A public inquiry is essential. If through a negotiated settlement, the case does not go to trial, then an inquiry of the sort and with the

powers of the investigation into the capsize of the Herald of Free Enterprise is the least that will meet the public interest.

Without it, there will be no basis for public confidence either in the pharmaceuticals industry's ability to strike a proper balance between safety and profit, or in the resolve of the Committee on Safety of Medicines to live up to its title. □

Radio two

IT IS nice to know that someone occasionally reads this page of *New Scientist*.

We have evidence for this from recent editions of the programme *Feedback* on Radio 4. There the BBC has been dragged over the coals by its listeners for failing to do right by science, an issue first raised on this very page (28 May, p 20). Most of the people who sent long and, to quote Chris Dunkley, the presenter of *Feedback*, well-argued letters agree that BBC radio does poorly by science.

The argument about science on Radio 4 actually smoked out the channel's controller and had him claiming that he had been personally involved in a decision to make programmes about superconductivity. At long last, if this claim is to be believed, there is someone in charge who takes science seriously. Now if only we can persuade the rest of the BBC to add science to the set of special subjects that, according to recent reports, it wants to see improved on television, we will indeed have achieved something. □

THIS WEEK

Britain proposes deal on Framework

B RITAIN is expecting to win agreement today from its European partners for a reduced budget for Framework, the EEC's programme for research and development. But other nations are less confident.

British officials in Brussels say that a draft proposal drawn up with the Commission and the Danish government (which currently holds the presidency) will be put to a meeting of the permanent representatives of all 12 member nations in Brussels today. If they agree, then approval at a meeting of research ministers later this month would follow. Britain's representative there will be the trade and industry minister, Kenneth Clarke.

The proposal is that Framework should receive funds over the next five years of 5.2 billion European Currency Units (ECUs). This is equivalent to around £3.7 billion and is roughly a continuation of current levels of funding for R&D. The European Commission's original proposal for Framework was almost double this sum.

A week ago, the Prime Minister, Margaret Thatcher, swept out of the Brussels summit meeting refusing to agree to the programme—or anything else for that matter—until the other nations had agreed to fundamental reforms to balance the EEC's budget. But it now appears that, amid the bluster, she came close to agreeing to a compromise on Framework that Britain has vetoed since last December.

For the past six months, Britain has held out for a ceiling for the five-year Framework programme of 4.2 billion ECUs. It steadfastly refused to accept a Belgian compromise for a budget of 5.6 billion ECUs, which has been on the table since the beginning of this year, and has been accepted by the 11 other nations.

Britain has apparently agreed that an extra 0.8 billion ECUs could be committed

Mary Fagan

as long as there were "watertight" guarantees that the money would not be spent until 1992. But the remaining sticking point is the difference between the Belgian compromise and the latest British offer. This amounts to 417 million ECUs, which Britain says it will not approve until it gets its way on the overall EEC budget deficit.

"The 417 million ECUs is not an integral part of the programme", British officials confirmed this week. They added that Britain would probably also demand today some assurances on a reevaluation of the role of the troubled Joint European Research Centres, which it regards as wasteful.

Some officials in Brussels reacted angrily to Britain's latest offer. The Dutch spokesman said: "I am very surprised that they expect agreement this week. We think 5.6 billion ECUs is already a minimum figure." Italy agreed that the only possible solution would be "if Britain decides to drop its reservations of the 0.4".

But British officials insisted on Tuesday that "the community is now very close to agreement on terms Thatcher set out at the summit in Brussels last week."

Meanwhile, the blame being accorded in Whitehall for Britain's failure to agree to Framework earlier this year has shifted. After resting with the Department of Trade and Industry, which has departmental responsibility, it shifted to the Treasury.

Now sources in Whitehall say that the Treasury has all along felt able to accommodate the Belgian proposal, and might "top up" the DTI's domestic R&D budget.

Instead, the Prime Minister herself is being held responsible.

At a meeting of permanent representatives in Brussels last week, after the summit, the other nations opposed any settlement of the Framework budget at 5.2 billion ECUs. They felt that enough cuts had been made already.

All 12 nations, including Britain, agreed however that there was an urgent need for decisions on three areas of R&D: medical research; RACE, the new telecommunications project; and science and technology for the developing world. But nobody is clear how this can be done without an overall agreement on Framework. The Single Europe Act, which recently came into force, does not allow it.

Roland Huber, at RACE, which has been on the starting blocks for many months, said that his team of 25 analysts from European telecommunications operators had already been disbanded.

● Meanwhile, doubts are being raised about the ability of the European Commission, the EEC's civil service, to direct Europe's technology policy effectively. At a recent conference at the Centre for European Policy Studies, Giorgio Spriano, a researcher at the centre, said that "the main problem lies with the political mandate and subsequently with the extent of autonomy delegated to the commission for long-term science and technology development."

Spriano believes that many programmes under the Framework banner, such as the initiative on information technology, ESPRIT, are too wide-ranging. He backs "mission-oriented" projects aimed at specific technologies or industries. They ▶

Sixth-formers create superconductor

SCHOOL students as well as researchers are superconducting. Six sixth-formers at Helsby High School in Cheshire have successfully made a high-temperature superconductor. They decided to have a go after reading an article in *New Scientist* (7 May, p 46). In the article, Paul Grant, a scientist at IBM's Research Centre in California suggested that the recent breakthrough in superconductivity could be repeated in a school laboratory.

The superconducting ceramic, which has produced euphoria in academic and industrial labs around the world, is an oxide of yttrium, barium and copper in the ratio of 1:2:3. It becomes superconducting at temperatures above that of liquid nitrogen.

"For about a £1, most schools could repeat the experiments that have thrown solid-state science into a turmoil", said the article. The chemistry teacher, Liz Cullen, at Helsby School took the suggestion seriously.

She found the starting materials easily enough. Copper oxide and barium carbonate were already sitting in the chemistry laboratory's cupboard. The third ingredient, yttrium oxide, could have been a problem. But Cullen once worked at ICI in Runcorn and she persuaded the firm to

provide the rarer oxide.

The pupils mixed the ingredients in the correct proportions and ground them with a pestle and mortar. They then commandeered the art room's pottery kiln and popped in the mixture, contained in the school's only silica evaporating dish. It took eight hours to cook. Cullen admits that the temperature of the kiln was a bit uncertain and could vary by as much as 100°C. So both teacher and students were delighted when they were able to demonstrate the "Meissner effect" using their own home-made ceramic.

The Meissner effect, in which a superconductor repels a magnetic field, is one of the tests for superconductivity. The students simply tied up the material with a piece of cotton and dangled it in liquid nitrogen—also obtained courtesy of ICI (Cullen warns that she was already used to handling liquid nitrogen in research).

The students then tried to suspend the material between the poles of a horseshoe magnet. But no matter how hard they tried to make the material enter the region between the poles, it remained well outside. Only when the ceramic warmed up above the transition temperature did it drop between the poles. □

OBSERVER David Austin

AS A HOUSEWIFE, NO DOUBT YOUR MRS. THATCHER FAVOURS DOMESTIC SCIENCE!



► should also be tied to contracts that ensure that the technologies turn into products.

"At present the commission would not have the political capacity to undertake more focused R&D programmes or to use procurement policies to support industrial development," he said.

Spriano believes that too much time has been spent at Brussels talking about budgets and too little on finding ways to give the commission the political mandate for a sales-oriented approach. He suggests the creation of a Common European Procurement Agency.

● While Britain continues to hold back Europe's R&D in information technology, there are renewed calls that its national initiative, the Alvey programme, should hold fire until Europe's effort is sorted out.

A report by the technology policy unit at the University of Manchester (PREST) on ESPRIT and Alvey, currently circulating within the Department of Trade and Industry and the European commission, says: "The rational approach is for the bulk of

national effort to be defined after the international strategy and programme is known".

The report's authors, Luke Georgiou and Hugh Cameron, say that a national programme should make domestic companies attractive as prospective international partners and provide insurance against the failure of international projects.

PREST's report is part of an overall evaluation of the Alvey programme to be published in the autumn. The subject of a follow-up to the original Alvey programme, now approaching completion, will be the subject of hot debate at the annual Alvey conference in Manchester next week.

PREST suggests that British firms could make fuller use of European money if the government or the Science and Engineering Research Council set up a "users club", to advise on contracts and make contact with prospective European partners. This idea contradicts the European Commission, which opposes national governments becoming involved in administering ESPRIT. □

Shake-up for helicopter safety

A RESEARCH project aimed at predicting the kind of failure in helicopters that killed 45 people on a Chinook last November began in Britain last week. The work will concentrate on Bristow Helicopters' Super Puma. Operators hope to make their helicopters safer within two years using measurements of vibrations to predict mechanical failures.

Meanwhile, British International Helicopters (BIH), the operator of the Chinook that crashed, is to decide this week how much money to put into the same kind of project.

Also last week, the Sheriff's Office in Aberdeen published its report on the Chinook crash. It found that a fatigue crack in the gearbox for the transmission for the front rotor caused both rotors to lose synchronisation. The blades clashed and ripped away the rear pylon, gearbox and rotor. The pilot could do nothing.

Stewart Bell, the principal sheriff, underlined in his report the importance of a new technology called "condition monitoring" for predicting mechanical failures. The work that began last week is to develop condition-monitoring systems.

Operators can already check the health of mechanical parts to some extent, by, for example, recording the temperatures of bearings on the drive shaft. High temperatures can show that the shaft is not evenly loaded. The new development is in monitoring vibrations. If a mechanism is working correctly, the frequency and amplitude of the vibrations it causes are different from when there is a fault.

Kit Chambers, the general operations manager of BIH, says that condition monitoring will predict failures, but more research is needed to help engineers to interpret correctly what the variations in frequencies means.

"In one tragic case in Australia," says Chambers, "a helicopter fitted with vibration-monitoring equipment crashed. It was only then that engineers understood what the trace was showing."

Westland Helicopters and Smiths Industries are participating in the project that began last week, along with Bristow Helicopters. The Civil Aviation Authority is funding much of this work, spending



Super Pumas will be safer soon

£800 000 on condition monitoring.

Engineers last week began fitting instruments to four of Bristow's Super Puma helicopters. For the next three months, they will record vibrations in flight. These data will go to Westland, which will use it to help modify the software developed for its system of monitoring conditions on its Westland 30 helicopter, so that it is suitable for the Super Puma.

BIH has not funded much research into vibration monitoring recently. "We were just not earning enough money to put anything into R&D," says Chambers. "Now things are looking easier and we are working on monitoring systems with Westland Smiths". □

Whitehall backs wave power

NEXT WEEK, work begins on Islay in the Hebrides to carve a column out of the coastal rocks. It will form the basis of a machine to generate electricity from the energy of the waves. Trevor Whittaker, a lecturer in civil engineering department at Queen's University, Belfast, is the project manager. The Department of Energy paid him to spend two years on a feasibility study, and is now putting up £230 000 for construction.

The idea is to create a "piston" of water in a vertical hole in rock. It is driven by the waves beneath and pushes air out through the top. A turbine generator at the top of the column taps the energy, thus created by the waves to produce electricity.

Norway has built a concrete water column in deep water to exploit this idea. Whittaker uses natural rocks found in shallow, craggy coastal areas. "Deep water yields more energy than shallow water, but by building the device at the end of a channel, we concentrate the wave energy so that we get as much energy as in a deep-water site." It is also cheaper. □

IT museum

THE SCIENCE Museum in London will play a central role in a £20-million project to build an information-technology museum in Berkshire. A special computer gallery in the Science Museum will act as a pilot for the main centre, on a business park near Reading.

The Information Age project is being organised by representatives from companies such as Digital Equipment Corporation, ICL and Harris Systems, as well as from the Science Museum and Berkshire County Council. □

Irish mustard

AN IRISH MP has asked the British government to investigate the fate of 25 000 tonnes of German shells and bombs containing chemical weapons, dumped 120 kilometres off the Irish coast in 1955 and 1957. Dinny McGinley, who represents Donegal, said he made the request via Ireland's foreign minister, Brian Lenihan. He wants to know what happened to a similar request made by the Irish Embassy in London last September. Health officials in Donegal are worried about possible leakage of phosgene and mustard gas from the shells. □

Cardiff's decision day

THE COUNCIL and Senate of University College, Cardiff last week accepted plans for a merger with the University of Wales Institute of Science and Technology (UWIST). The merger is at the insistence of the University Grants Committee, which made it a condition of stepping in to relieve University College of a large debt (*New Scientist*, 2 July p 27).

The grants committee is meeting today to decide the future of the college. UWIST was still examining the merger plans early this week. But it is being offered a majority on the group that will finalise details of a merger and, if all is agreed, on 1 October, Aubrey Trotman-Dickenson, currently principal of UWIST, will become principal designate of the new institution. □

New date for Ariane

THE end of August now seems the most likely time for the launch of the first Ariane rocket since the catastrophic failure of an Ariane II in May last year.

Arianespace is now conducting the final tests on the cryogenic engine for the flight. The engine's failure to ignite last May caused mission controllers to destroy the rocket. An inquiry found that the first ignition failed, and that the second ignition failed 0.12 seconds later, because of abnormally high pressures in the combustion chamber. □

Geologists make their bid for freedom

THE BRITISH Geological Survey should be given independence from the Natural Environment Research Council (NERC). It should have direct access to a government minister and be given an annual guaranteed grant. So concludes a study of the survey and national geological needs chaired by Sir Clifford Butler.

The study, announced by the Prime Minister last August, arose after escalating complaints by geologists that the work of the survey was being hampered by constraints imposed by the NERC, which has been in charge of the survey for 20 years. The government had asked the NERC to channel more of its money to universities, rather than large research institutes.

Geologists argued that the survey was vital to the national well-being. They claimed that their science underpinned £40 billion worth of national output a year—from mineral and oil revenues and research into nuclear waste and such. Now the Butler report, presented to the government's Advisory Board for the Research Councils (ABRC) as well as the NERC, largely backs their case.

It is certain to receive a frosty reception from the NERC. The council's director for Earth sciences, Jim Briden, told Butler in his evidence that the survey should stay where it is.

If there were a ministry for research, there might be a case for it being attached to a single government department, "but I do not suppose for a moment that arrangements for the geological survey are going to be the catalyst for a grand reshuffle of departments of state".

The terms of reference given to Butler did not include the survey's relationship

Richard Fifield

with the NERC, but concentrated on national requirements for geological surveying. However, many people giving evidence raised the issue, and the ABRC and NERC agreed that these representations should be noted, though "they would be considered subordinate to the assessment of the national needs".

Butler says that the survey should continue to be responsible for a core national programme of surveying, mapping, the maintenance of the National Geosciences Data Centre and some research. He also calls for legislation to

The core programme, says Butler, should be publicly funded at a rate of £15 million a year, to be reviewed every three years. It should be allowed to earn up to £3 million a year from commercial spinoff in the form of maps and data without losing grant, but the core programme should rely less on such spinoff. In recent years, such work has received around £10 million a year from the government and £6 million from spinoff.

Butler calls for the survey to produce its maps more quickly and to respond more quickly to requests from clients and government departments. New techniques involving computers should help to speed up the map-making processes, he says. The survey already earns about £10 million from work on commercial contracts outside its core work.

Butler stresses the importance of hydrogeology and backs the survey's proposals for a crash programme to complete a resurvey. The current maps for some parts of Britain were surveyed and printed before 1870.

The survey should have a new management structure with a board of 12, including the director and three or four senior members of the survey, plus industrialists, academics and the NERC's director of Earth sciences. The chairman, Butler says, should be independent, part-time and appointed by the Prime Minister.

Butler rejects privatisation of the survey, because of the extent of its core work, which no private company would want to take on. Instead, it should have a similar status to the Ordnance Survey, "with a direct line of approach to government and thus able to play an active role in the formation and implementation of national policy".



Core research: Briden (left), wants the NERC to keep control

extend the rights of the survey to geological information obtained by mining companies and others sinking boreholes.

The survey should respect commercial confidentiality, but should be allowed to integrate such private information into its databases and maps, and make it available in this form to customers.

Peer review rocked by argument over seismic centre

THE NATIONAL Science Foundation in the US is being urged to change its mind about establishing a centre for earthquake engineering in New York, instead of California. The demand comes from a senator from California and follows an investigation by the General Accounting Office (GAO), which found that a panel set up by the foundation mishandled a national competition among universities to house the centre. Senator Pete Wilson wants the competition to be held again.

The foundation says it will not budge. The argument could flare up into a battle over the independence of the foundation to award research grants based on peer review.

The decision to build the \$25-million National Earthquake Engineering Center at the State University of New York in Buffalo infuriated scientists and politicians in California when it was announced last September (*New Scientist*, 2 October 1986, p 17). Other universities on the east coast, including Columbia and Cornell in New York and Princeton in New Jersey, will also

be involved in the centre. Several of the nine campuses within the University of California are world leaders in earthquake research. Also, California is far more prone to earthquakes than any other state.

Wilson asked the GAO, a branch of Congress, to investigate the decision. The GAO's report was released last week.

It rejected charges by Wilson and others that the panel set up by the foundation to review proposals for the centre was unqualified and biased in New York's favour. However, it did find that the foundation had not adequately documented why Buffalo deserved the award over the other states. And it said that the foundation had failed to make it clear by what date competing states should have matching funds available to qualify as bidders.

The confusion caused the foundation's panel to postpone a visit to Berkeley, the site in California proposed for the centre. By the time it did visit Berkeley, the panel had already "conditionally" recommended that Buffalo win the award.

An earlier investigation by the foundation itself found that portions of the proposal submitted by the Buffalo consortium bidding for the centre included material copied from papers published in California.

John Moore, deputy director of the foundation, strongly defended its action last week. "The NSF made the right decision in fair and open competition. Certainly there is nothing in the report that would warrant reopening the grant process," he said.

Wilson threatened last week to introduce legislation to block any more money being awarded to Buffalo. He also wants a congressional investigation of the process by which the foundation's grants are awarded.

There is growing concern in Washington that Wilson's campaign may turn into a witch-hunt against the foundation. Congress, say some science policy-makers, should not intrude legislatively into what is supposed to be an independent review.

Ian Anderson, San Francisco

Row over anencephalic babies reaches Britain

LIFE, the anti-abortion organisation, is stepping up its campaign to "safeguard the unborn child". Its latest move is to focus on surgeons who transplanted a heart from a baby born without a brain, in Ireland.

Magdi Yacoub of Harefield Hospital outside London is under investigation by the Director of Public Prosecutions, following a complaint by Life. It accuses him of removing organs from an anencephalic baby before it was dead.

Anencephalic babies have no cerebral cortex, but they may possess a brain stem, which controls breathing and certain automatic functions. Nonetheless, they inevitably die, within a few hours of birth. In the US last year, wrangles over harvesting organs from anencephalics focused on legal definitions of death (*New Scientist*, 6 November 1986, p 20).

John Dawson, secretary of the British Medical Association, declined to comment on the case. However, he said: "It would be sensible not to take transplants from anencephalic infants until guidelines are clarified."

The legal definition of death in Britain is the irreversible cessation of function in the brain stem. "Because anencephalics lack higher centres, they do not fall within the present definition," Dawson says.

A committee chaired by the Sir Raymond Hoffenberg, president of the Royal College of Physicians, is now reviewing the issue, says Dawson.

Life is also backing an amendment to the Infant Life (Preservation) Bill of 1929 that would make abortions in Britain legal only



Today took up Life's case on Monday

up to 24 weeks, instead of 28 weeks as at present.

A select committee of the House of Lords, reviewing the evidence, concludes in a study published last week that it "would be premature for the committee to make any recommendation" as to whether the bill should proceed.

At issue are some 30 abortions, out of 170 000 carried out each year in England and Wales, that are performed after 25

weeks. These late abortions, says Wendy Savage of the London Youth, are associated "with low, low intelligence and severe mental illness usually in a context of social deprivation".

Some late abortions may also be anencephalic fetuses diagnosed at a late stage, says Charles Rodeck of the Royal Postgraduate Medical School. "Because anencephaly is invariably fatal, it has long been accepted obstetric practice to terminate the pregnancy at whatever stage it was discovered."

Carrying such a fetus to term, he says, may be damaging to the mother, both physically and mentally.

Life, however, disagrees. In evidence to the select committee, it says: "It seems particularly lamentable that very late

abortion should continue unchecked in this country and that any restriction should be opposed on the ground that it is necessary to be able to 'weed out' the handicapped in utero."

Weeded out

MINISTERS have drawn up a shortlist of three companies that want to buy the Plant Breeding Institute and the National Seed Development Organisation in Cambridge. The three companies, Booker, ICI and Unilever, will now have access to detailed figures on the assets of the two organisations. Their final bids, which they will submit by the end of this month, could be anything up to £70 million. The government is expected to announce the buyer before the start of parliament's summer recess.

The three companies are interested in the institute's biotechnology research, which is becoming increasingly important in the development of new varieties of crops. ICI, a chemicals company, bought a Belgian seed company last month for £93 million, and, like Unilever, which has a large interest in package foods, also has a research centre devoted to plant biotechnology. Booker, which has a broad interest in foodstuffs and consumer goods, wants to diversify into plant breeding and biotechnology.

Rural rides

DEATH on the roads is far more common in rural areas of the United States than in the more densely populated east. One reason is the higher traffic speeds in rural areas, causing more damaging accidents.

The wide open spaces of Esmeralda County in Nevada, which has a population density of 0.1 persons per square kilometre, have an annual death rate of 1.86 per 1000 residents—100 times higher than the congested city streets of Manhattan.

Writing in the *New England Journal of Medicine* (vol 316, p 1384) Susan Baker of Baltimore's Injury Prevention Center, also singles out the absence of emergency care in rural areas.

Opren takes long road to court

LEGAL manoeuvres last week over an action brought by victims of Opren, a drug prescribed until 1982 for arthritis, mean it will now be at least two years before the case comes to court. By then, many of the elderly plaintiffs could be dead.

Last week, the manufacturer of Opren, the American firm Eli Lilly, broke off negotiations for an out-of-court settlement. It claimed that most of the complaints concerned side-effects listed in the Data Sheets on the drug. "I don't think any pharmaceutical company can contemplate the principle of compensation to people suffering side-effects that were warned about," he said.

The stakes are high. Eli Lilly is accused of negligence in the development of the drug and misrepresentation in its marketing.

For the love of Lovell

JODRELL BANK's large radio telescope has been named the Lovell Telescope, after the astronomer who conceived it, Sir Bernard Lovell. The Duke of Devonshire named the telescope at a party for the telescope's thirtieth birthday.

Lovell's personal enthusiasm and persuasion were directly responsible for the construction of the telescope, which for many years was the largest in the world. Because the costs overrun considerably, Lovell was at one point threatened with legal action that would have landed him in gaol.

The government's Committee on Safety of Medicines (CSM) is also a plaintiff.

The Opren Action Committee, which represents most of the claimants, has questioned the scientific competence of Lilly's staff, both in Britain and in the US, in designing, carrying out and interpreting animal and human studies on the drug.

And the action committee says that if the CSM had made a proper study of the firm's reports in support of its application to market Opren, then it would have either refused the application or demanded changes in the recommended dose and in information published on side-effects. In the US, the company has already been fined for misleading the CSM's opposite number, the Food and Drug Administration.

Doctors, too, are involved. Eli Lilly's claim that it gave proper information on side-effects implies that doctors were responsible for injuries to their patients.

Warnings included in the Data Sheets covered a wide range of adverse reactions, including effects on kidney and liver function and skin sensitivity to light. However, the effects turned out to be much more severe than the company expected, as a comparison of the warnings in Data Sheets published in 1980 and May 1982, shortly before the drug's withdrawal, show.

One charge against the company is that it should have included the tougher warnings in 1981 or even 1980.

How Toshiba sold secret of silent submarines

ILLLEGAL export of sophisticated technology to the Soviet Union has sparked off a renewed trade war in advanced technologies. Toshiba Machine Tool is alleged to have seriously damaged Western security by enabling the Russians to make very quiet submarine propellers that can elude detection by Western defence forces.

Now the United States' Senate has voted to ban all products from the parent company, Toshiba, from sale in the US. Toshiba sells about £1.7 billion worth of goods in North America every year. Meanwhile, the chairman and president of the subsidiary have resigned.

In 1982 and 1983, Toshiba sold four MBP-110 machine tools, each costing more than \$4 million, to the USSR. The machines have nine independently controlled axes, each allowing the machines to shape the metal in a different plane. This sale broke the rules of COCOM — the Coordinating Committee for Multilateral Export Controls — of which Japan is a member. COCOM's regulations state that advanced machine tools with more than three independently operating axes should not be exported to the Eastern bloc. Toshiba got around the rules by saying in its export application that the machines had only two such axes. Now the Japanese government has stopped it from selling anything to the USSR and its allies for one year.

Because the Soviet Union now has the ability to make very quiet propellers, American technology to detect submarines will have to be

Mary Fagan

updated. The United States Navy says that this will cost at least \$1 billion. Defence analysts say NATO's entire submarine detection systems must be revamped.

Traditional propellers produce a cavitation effect in water. They form and then break vacuums as they turn around in the water. The noise of the bubbles breaking can be heard by passive sonars on the coast or the sea bed. The US has arrays of sonars covering the sea routes between Greenland, Iceland and Britain, for example, to spot Soviet submarines leaving ports in the northern Soviet Union.

Defence scientists believe that submarines are now becoming so quiet that

passive sonars will have to give way to active sonars that send out a signal to bounce off targets. Some American defence analysts claim that the Soviet Union can now make submarines so quiet that the range of some American detectors will be cut from 150 kilometres to 15 kilometres.

Reaction in the US to Toshiba's action was violent. Although the parent company stresses that it has nothing to do with the day-to-day running of Toshiba Machine, it almost immediately lost the chance of an order worth \$100 million to supply lap-top computers to the Pentagon. Some Congressmen smashed up Toshiba products on the White House lawn.

The defence secretary, Caspar Weinberger, led a three-day meeting in Tokyo in a positive mood saying that the important thing was not to press for compensation but to talk of "regaining, keeping and strengthening antisubmarine warfare leadership". Senate disagreed. On 1 July, it voted by 92 votes to 5 to ban all Toshiba products for between two and five years.

If the ban becomes law, it could rebound on American industries. Toshiba is one of the world's largest manufacturers of semiconductors. It has 33 per cent of the world market in 1 megabit DRAMS — memory chips needed for computers. Already some American computers companies are complaining of shortages caused by trade friction between the two countries.

Toshiba says that it hopes to stave off the ban by allowing the US administration to audit its accounts. They are also hoping that Ronald Reagan might veto the ban. □



IS THIS the fist of the Colossus of Rhodes' or a stunt to drum up tourist trade? Divers show off last week's find from the Greek harbour. Now it is the archaeologists' turn.

Today, Britain's TV industry dies

HALF a century ago, Britain led the world in television, thanks to the all-electronic technology invented by EMI. From today, the British TV industry will be almost wholly owned by foreign companies. The only original research into new technology will be done abroad.

The reason is that Thorn EMI today sells Ferguson, Britain's last remaining major TV manufacturer and innovator, to the French electronics giant, Thomson, for £90 million.

The foreign invasion began in June 1973, when Sony built a TV factory in Bridgend, South Wales, just six months after Britain joined the EEC.

Then Matsushita, which makes Panasonic TV sets, opened a factory at Pentwyn, near Cardiff. Hitachi tried to do likewise, but faced fierce opposition from both trade unions and Lord Thorneycroft, then Chairman of the Radio Industry Council. Hitachi's cohorts from Japan were dubbed "the hit men" and withdrew, blaming "the current climate of intense opposition".

Hitachi finally struck a deal with GEC, Britain's largest electronics company, to

create a £5 million joint manufacturing venture in GEC's existing TV factory at Hirwaun in South Wales. The venture soon turned sour with strikes, redundancies and a wage freeze. Annual losses at Hirwaun topped £5 million and in 1984 Hitachi bought out GEC. The Japanese management has since imposed iron rule on a disenchanted workforce. Workers over 35 years old have been asked to retire because they are too old.

Meanwhile, another Japanese company, Mitsubishi, built a factory in Scotland and complained that school leavers did not take work sufficiently seriously.

The largest native British TV factory, owned by Rank in Plymouth, also failed. Another Japanese company, Toshiba, bought a stake in a joint venture to run the plant. The British government contributed £2 million but, after two unsuccessful years, the factory closed.

Toshiba bought the premises and re-employed 300 of the 3000 sacked workers. Under Japanese ownership, the Plymouth plant has expanded and is now making microwave ovens and video recorders as

well as TV sets. Tatung of Taiwan meanwhile, has bought and revived Decca's TV factory in Bridgnorth. Sanyo has bought a factory in Lowestoft in Suffolk, vacated by Philips.

None of the foreign firms has a research centre in Britain. All their design work is carried out in laboratories in the Far East. Of the major Japanese electronics firms, only Sharp and JVC have not bought or built factories in Britain.

Ferguson, the last British factory to fall, employs 5000 people to research, design and manufacture TV sets in three factories at Enfield, Gosport and High Wycombe. After heavy investment in new automated plant, Ferguson won an order from Japan to make British sets for sale under the JVC brand name.

If Thomson buys Ferguson, future profits from this contract will go to France. There will then only be one British TV factory left in Britain, the Fidelity plant, which employs 500 in North London. This was recently bought by the Caparo group, which is owned by Swraj Paul, a naturalised Briton. □

Pesticide famine leaves Ethiopia open to locust plague

ETHIOPIA has run out of pesticides that could stem the plague of desert locusts now devastating crops in the north of the country. Stocks have been exhausted by extensive spraying last month, especially in the northern city of Asmara, where the airport had to be closed after dead insects piled up on the landing strip.

The Ethiopians say they have been attempting to obtain foreign assistance for chemicals and spraying equipment through the UN Food and Agriculture Organisation. But potential donors complain that the FAO had described the situation as "under control", until as late as 19 June, when it abruptly called a special meeting of donors to ask for help.

Lukas Brader, the head of locust control operations at the FAO's headquarters in Rome, said this week that he will provide help to the Desert Locust Control Organisation (DLCO) in Addis Ababa "if the donors react". But "this is not yet finalised", he said.

The crop protection division of the Ethiopian ministry of agriculture describes the spread of the desert locusts as "quite alarming". The locusts bred last month in the dry lowlands of Eritrea, in the northeast

of the country, and have now formed mature swarms that are heading for the farming areas of the highlands.

By the end of June, five swarms had moved into the Tigrean highlands, and a swarm one kilometre long and 300 metres wide had been spotted southwest of the former relief camp at Mekele. This week, locusts are reported to be damaging crops of sorghum and millet in the northern province of Tigre.

The DLCO declared a locust emergency as long ago as February, when the return of the spring rains provided good news for farmers and locusts alike. Three months later, the rain was still falling, a highly unusual situation which allowed the locusts to produce a second bumper generation.

The incipient swarms could have been destroyed in the spring. The Ethiopian agriculture ministry launched spraying operations but, say its locust experts, there are always a few that get away and cannot be chased across vast, sparsely populated regions such as Eritrea.

The FAO has developed a way of monitoring the appearance of green vegetation in the desert using inexpensive images from weather satellites. These green patches pinpoint breeding sites for locusts, in theory permitting teams of sprayers to go directly to a new outbreak.

But Ethiopia's crop protection specialists do not receive the satellite images from the DLCO because the organisation has only recently been able to afford to train one person to interpret them. Meanwhile, the DLCO tells the Ethiopians what general regions it believes harbour locusts, and the Ethiopians then leap into their Land Rovers to check parts of the desert they know from past experience may be breeding sites.



The ministry of agriculture has only three Land Rovers for monitoring the several kinds of locusts, as well as other pests, such as army worms and quelea birds, that can crop up anywhere in Ethiopia's vast, isolated farming regions.

France and Sweden have bought Ethiopia new vehicles, that will permit five teams to operate in locust-prone regions. Each team will have a Land Rover equipped with a sprayer, a staff car and a lorry for pesticides. But the first Land Rover arrived in the Port of Assab only last week.

If the swarms aren't controlled now, experts in Addis say they could cover the farms of the African Sahel, and could also infest the entire Red Sea coast. Depending on winds and rains, swarms could move south over crops in the Ethiopian provinces of Wollo and Harar, and move into the Ogaden desert in time to breed again when the rains come next spring.

But Ethiopia is almost out of pesticides. Last week, the FAO's office in Addis reported that 30 000 litres of fenitrothion were used in the country in June. Asmara received a delivery of over 9000 litres at the end of June.

Aynakulu Yemana, of the crop protection division at the Ethiopian ministry of agriculture, estimates that to control this outbreak, operations will have to extend into 1988, and will require 100 000 litres of insecticide, 200 more motorised "knapsack" sprayers, five more Land Rovers, about 15 radio sets to allow field teams to communicate, and even such basic equipment as tents for the spray teams. The equipment would cost over \$1 million. Ethiopia does not have it now, and may not get it in time.

Debora MacKenzie, Addis Ababa

Ozone deal

THE WORLD'S industrial nations agreed in principle last week on a formula for cutting chemical emissions that harm the ozone layer. It is now likely that a treaty to protect the ozone layer will be signed in September.

Ozone in the Earth's stratosphere absorbs most ultraviolet sunlight before it reaches Earth. Depletion of ozone will increase damage from ultraviolet light to living things, and could also change the world's climate.

The treaty to protect the ozone layer, which is being promoted by the UN Environment Programme, centres on reducing the production of chlorofluorocarbons (CFCs), found in refrigerators, aerosol sprays, plastics foam and the electronics industry. CFCs are stable enough to persist in the atmosphere, and drift into the stratosphere where they destroy ozone.

The aim of the proposed treaty is to reduce the world's production of stable CFCs and to encourage alternatives. Chemical companies support this in principle. Commercial tensions have caused rows among industrial nations on how to limit CFCs. But at an informal meeting in Brussels last week, the EEC dropped its objections to a proposal worked out in Geneva in April (*New Scientist*, 30 April, p 25).

The EEC had backed a reduction in production of 20 per cent, but until last week, had opposed a second 30 per cent reduction in six years' time. Now it wants the second round delayed by four years.

Legal experts from industrialised countries and the UN meet in the Hague this week to draft a form of words for the treaty. There may still be objections from the Soviet Union and Japan. Japan considers some CFCs vital for its electronics industry. □

Europe's trees sicken further

THE FIRST Europe-wide survey of the health of the continent's trees has found deterioration among broadleaves and confirmed the poor state of conifers. Britain has as high a proportion of damaged conifers as any country in western Europe.

The report of an international cooperative programme, to be published later this month, warns that the number of ill trees is "intolerably high" and says that air pollution is "an essential causal factor in the destabilisation or even breakdown of forest ecosystems".

Britain's Forestry Commission is alone in claiming that climate and fungi are most to blame. Trees on high mountainsides fared worst in the survey, which looked at 150 million hectares of forest in 15 countries in both East and West Europe. □



AIDS MONITOR

Researchers hunt the weak link



THE MORE that scientists can find out about the human immunodeficiency virus (HIV), the better their chances, or so they anticipate, of designing drugs and vaccines to prevent HIV from attacking

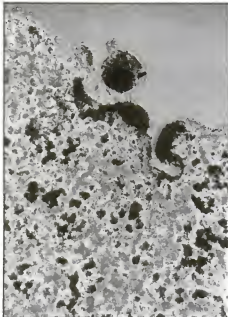
human cells. There are several points in the life cycle of the virus when it might be vulnerable to intervention. One is the stage at which the virus binds to the white blood cells called T4 lymphocytes.

A group of researchers at the Harvard Medical School and Harvard School of Public Health in Boston, Massachusetts, is studying the process of binding in great detail. Joseph Sodroski, William Haseltine and their colleagues are beginning to identify which parts of the viral envelope proteins are involved in binding, and precisely how the virus enters the cell. Their work also provides one explanation of how HIV kills the cells that it attacks.

When HIV binds to a T4 lymphocyte, the viral envelope protein known as gp120 attaches itself to receptor molecules, called CD4, which are present on the surface of the T4 cell. However, infected cells also carry viral proteins on their membranes. These proteins presumably congregate on the cell surface as a prelude to budding of new viruses.

Sodroski and his colleagues have turned this characteristic of infected cells to advantage, as they reported at last month's Third International Conference on AIDS in Washington. They have inserted the gene for the viral envelope protein into lymphocytes, along with a second gene. This second gene codes for a protein which has the effect of increasing the output of the first gene, so that the cell makes large amounts of envelope protein.

Viral envelope protein expressed on the surface of a T4 cell acts in much the same way as it does if it happens to be inserted in the membrane of a virus. When infected



A virus breaks loose from an infected cell. Will science ever break the cycle?

L. Montagnier, Institut Pasteur/SPR

cells are grown in tissue culture, they bind to each other. The cells then fuse. Large cells with many nuclei result, which go on to die.

Cells do not have to fuse in order to die, however. If a cell has large numbers of envelope proteins and CD4 receptors on its surface, these molecules may also interact with each other. The binding and fusion of adjacent parts of the membrane that results may disrupt the membrane of the cell so much that the cell dies.

The next step for Sodroski and his colleagues was to introduce mutations into the gene (*env*) that they had inserted into the T4 cells. "We wanted to know what effect this would have on the function of binding and fusion," says Sodroski.

The *env* gene of HIV supplies the genetic information for a protein called gp160. This protein splits to form two molecules—gp120, which binds to CD4, and gp41,

which sits astride the membrane, whether this is the membrane of the infected cell or that of the virus.

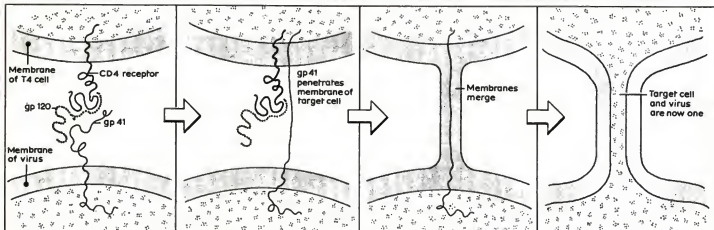
From studying the ability of cells carrying the mutant *env* genes to bind and fuse, Sodroski and his colleagues have produced a step-by-step theory of how binding and fusion happens. First of all, a bridge forms between the two membranes. These might be the membranes of two cells—one infected and one uninfected—or the membrane of a virus and that of an uninfected cell. A third prerequisite is a molecule of gp120. Again, this might be attached to a virus or an infected cell, or even floating freely in the tissue culture fluid.

The bridge forms as follows. One end of the gp120 binds to the CD4 receptor on the cell membrane. The other end of the gp120 is loosely associated with a molecule of gp41 on the viral membrane (or on the membrane of an infected cell).

Next, says Sodroski, comes fusion. The two membranes come closer together, perhaps as a result of the gp41 molecule shortening in length. This process could be stimulated if parts of gp41 prefer an environment containing little water. The internal layers of cell membranes are also hydrophobic (water-hating), so this theory could explain how gp41 manages to pierce the membrane of the adjacent cell.

Sodroski and his coworkers now know which parts of the *env* gene they have to change in order to alter the function of the two viral proteins involved in binding. One type of mutation turns out to disrupt the association between gp41 and gp120, for example. Another prevents one end of gp120 from binding to the CD4 receptor. Further mutations disrupt the ability of cell membranes to fuse. Finally, another group of mutations affects the anchorage of gp41 in the membrane, so that it falls out.

The same group of researchers is now going on to examine ways of modifying these regions of the virus's genome. Such work could eventually help to provide the key to antiviral therapy. Sodroski says: "These are critical processes that are reasonable targets for intervention." □



The proteins gp41 and gp120, found in the envelope of the virus, play a vital role in binding to the CD4 receptor molecule. Fusion of the membranes follows, and the contents of the virus merge with the cytoplasm of the target cell

Secret tests may have negative side effects

LAST WEEK, the British Medical Association voted to allow secret AIDS tests on patients. The decision has left the BMA open to allegations that it condones action that could drive the disease underground. It also threatens to damage the relationship between doctor and patient.

The decision "that testing for HIV antibody should be at the discretion of the patient's doctor and should not necessarily require the consent of the patient" was taken by 183 to 140 votes at the association's annual conference in Bristol. In voting for this, representatives are now out of line not only with their own council, but also the Department of Health and Social Security and the World Health Organisation.

Few people fail to sympathise with doctors' fears of catching AIDS from their patients. As Laurie Allan, an anaesthetist in London, told the meeting: "I, for one, feel my life and those of my colleagues are more important than the future employment and insurance prospects of infected individuals."

The debate that followed was one of the most emotional and chaotic in the association's history. But delegates spent little time discussing the consequences of the



Blood sampling is routine, but what tests will follow?

proposed action, and the effects it might have on high-risk groups.

John Chisholm, a general practitioner in Reading, was the only doctor to point out that any move to test people without their knowledge will create mistrust of doctors".

Warnings from John Marks, chairman of the council of the BMA, also went unheeded. He said it was precisely because AIDS is different, and because there is no cure, that it should be treated sensitively. He also pointed out that taking a blood test without consent "is an offence in law".

After the debate, the BMA's undersecretary, John Dawson, warned that the decision would not necessarily protect doctors. Not all AIDS victims show positive in the early stages, he explained. If doctors fail to take precautions with every patient, including those whose tests are negative, they will still be at risk.

The Terrence Higgins Trust called the decision "a great step backwards for the medical profession." One of Britain's leading specialists on AIDS, Mike Adler of the Middlesex Hospital, summed up many people's worst fears. "Allowing potential patients to feel that any doctor sticking any needle into them may be testing for HIV without consent will inevitably drive risk groups underground," he said. □

Known risk factors explain high rates of infection in Florida

AMERICAN scientists have confirmed that mosquitoes fed on a meal of blood containing the human immunodeficiency virus (HIV) do retain the virus in their digestive systems for a short time. But experts have repeated that there is no evidence and scant likelihood that these insects could transfer the virus to other organisms.

The experiments, by Jai Nayar, an entomologist working in Florida, are the latest in a series of tests to determine whether insects can carry HIV. Nayar carried out his experiments in collaboration with the US National Cancer Institute in Bethesda, Maryland, and Biogenetics Research, a company near Bethesda. Virologists at the Centers for Disease Control, also in Bethesda, at the Pasteur Institute in Paris, and in Africa have previously come to similar conclusions.

Concern about a possible role for insects in transmitting HIV has arisen in part from the curious course of AIDS in Belle Glade, Florida. Over the past five years, 76 people in this town of 16 500 have contracted AIDS—a rate of 461 per 100 000 population. This level of infection is comparable to that in the areas of highest risk, San Francisco and New York City.

Some scientists suspected that mosquitoes were to blame. But investigators from the Centers for Disease Control this year found that use of intravenous drugs, prostitution and promiscuity are common in the town. Many of the people in Belle Glade also come from Haiti, where there is a high level of infection with HIV. Furthermore, most cases were among young

adults; there were no cases among children or the elderly. If mosquitoes were the culprits, these groups would undoubtedly have succumbed to HIV as well.



Drugs and sex—but not mosquitoes—may spread AIDS

Thomas Monath, a virologist with the Centers for Disease Control, says: "The bottom line is, no... there is no evidence that the virus can replicate in insects or be transferred." Monath has infected bedbugs with HIV. He notes that Nayar's research confirms his results and those of French researchers.

Insects can transmit viruses in two ways. Mechanical transfer is one possibility. Alternatively, the insect itself may become infected. In this case, the virus replicates in the insect's tissues and salivary glands. The insect then transmits the virus to another host through its saliva.

HIV, however, appears to reside in bedbugs only in blood from the host that remains on the insect's mouthparts or in its gut. Two other retroviruses, the family from which HIV comes, can be passed on

in this manner: equine infectious anaemia and bovine leukaemia.

Monath says: "What is unique about those [infections] is that the content of those viruses in the blood of the donor is extremely high." To transmit these forms of anaemia and leukaemia, Monath explains, the blood must contain over one million viral particles per millilitre of blood. The blood of patients with AIDS usually contains less than 10 viral particles per millilitre.

In addition, the volume of blood that an insect such as a bedbug can transfer mechanically is about one fifteen-thousandth of a millilitre. "It would take many thousands of feedings by an insect from an infected person, and then refeeding on a susceptible person, to infect someone."

Monath says. He points out that among healthcare workers who have stabbed themselves with a needle contaminated with infected blood, only about three in 1000 become infected. Monath has calculated that the blood on a needle is about 140 times the amount of blood on the proboscis of a bedbug.

Nayar fed his mosquitoes on blood that was heavily enriched with HIV. Newspaper accounts of his results quote him as saying that HIV can live for two or three days in a mosquito. Robert Gallo, one of the US's experts on HIV, agreed that there is no evidence that these mosquitoes could transmit the virus to humans. □

AIDS Monitor is edited by Sharon Kingman, with contributions this week from Christopher Joyce and Toni Turner.

New insights into early embryos

While the makers of test-tube babies worry about their public image, research uncovers ways of diagnosing genetic diseases in embryos

Gail Vines

CLINICIANS and researchers in the world of "assisted reproduction" continue to develop the science and art of "test-tube babies", while arguing furiously among themselves as to the proper directions of their work. Debates at the third annual meeting of the European Society of Human Reproduction and Embryology in Cambridge last week centred around two issues: how many embryos or eggs should clinicians transfer to a would-be mother, and are we ready to begin testing embryos for genetic defects? Fueling both debates was the worry that a backlash in public opinion against a particular practice could lead to legislation that would ban research on human embryos.

The row about the number of eggs or embryos stems from a pronouncement in this year's report from the voluntary licensing authority (VLA), set up in 1982 to act as a watchdog over research and clinical practice. Last month, the VLA said that not more than three embryos, or in exceptional circumstances four, should be transferred to a woman's womb after *in vitro* fertilisation (IVF). The VLA has set the limit to minimise the risk of multiple pregnancies, which can endanger both the mother and her babies. The same restrictions apply to the newer technique of GIFT (gamete intrafallopian transfer), in which eggs and sperm are transferred directly into a woman's fallopian tubes. Doctors have until September to comply with the VLA's guidelines or lose their licences.

How many is too many?

Most clinicians working in the field are happy with the "recommendation" and have modified their clinical practice accordingly. Ian Craft and his colleagues at the Humana Hospital Wellington in London, however, vehemently oppose it. He argues that his clinic's experience with GIFT shows that 85 per cent of the pregnancies are singletons, and only 1 per cent quads, even when he transferred 11 eggs or more. The women who produce that high number of eggs, after treatment with "fertility" drugs, tend to be older women, often with polycystic ovary disease. "These women have a lower success at getting pregnant," Craft said. "If you reduce the number of eggs transferred to less than four, you reduce their chances even further."

The problem is what to do if a rare multiple pregnancy does happen. Craft and his colleagues have performed "selective terminations", killing one or more fetuses in the womb by puncturing their hearts. The alternative is to continue all pregnancies to term, which can endanger the life of the mother and produce babies that need intensive care after birth.

Robert Winston of the Hammersmith Hospital in London says this puts IVF and

GIFT "on the edge of a minefield. What we do is under close scrutiny. We may damage our own subject unless we control ourselves carefully. Terminating a pregnancy that we have induced is different from terminating a spontaneous pregnancy."

Underlying the debate about the ethics of selective abortion is a battle over the independence of the clinician. "We think we should have a flexible approach," says Craft. "It is a clinical decision, with the patients having some say in the matter. The VLA should make recommendations rather than rules." A straw poll of the audience at the meeting suggested that Craft was not alone in this view. The vast majority wanted guidelines, but not legal strictures, on the transfer of embryos.

Meanwhile, Mary Warnock, chairman of the VLA, called for legislation to establish a statutory licensing authority to license clinicians and researchers, clinics and laboratories and individual projects. She also argued, in line with her committee's report, that it should become a criminal offence to retain in culture a human embryo older than 14 days. This is a convenient "legal point when we begin to treat the zygote as an individual," she says. At 14 days the primitive streak, which will go on to form the central nervous system, begins to form. "Before this it is possible that two or no embryos will develop out of the cluster of cells. It may be inappropriate to speak of the early embryo—which is neither singular nor plural."

Research on embryos younger than 14 days is not only legitimate but essential, Warnock said. "If the techniques of treating infertility through IVF are to continue, research is necessary. Irish obstetricians who say they want to have IVF without research are simply riding on the backs of others." All these debates would be settled, Warnock argued, by legislation modelled on the bill that controls animal experiments in Britain. The Queen's Speech a few weeks ago, however, contained no mention of a government bill on the new reproductive technologies.

While we wait for legislation, collaboration between molecular biologists, embryologists and obstetricians is opening a new era in "assisted reproduction". Genetic tests for human embryos are imminent, according to many scientists and clinicians at the meeting. This would mean that couples at high risk of producing children with a serious genetic disease, such as Duchenne muscular dystrophy or beta thalassaemia, would no longer have to go through the trauma of aborting fetuses detected later during pregnancy. Scientists could test the DNA of an embryo for a specific genetic defect in the laboratory and introduce into the womb only unaffected embryos.

Robert Edwards, of Bourn Hall and the University of Cambridge, thinks that things

are moving too fast. "Molecular biologists are actually ahead of us. They are producing techniques that we can't use. We embryologists have to work harder," he says. But Robert Winston disagrees: "It has been done in animals, and there comes a point when you can apply that work to humans." Bernadette Modell of University College Hospital in London says she knows of couples who are at high risk of producing a child with thalassaemia—and who have had repeated terminations of affected fetuses—who "would be prepared tomorrow to take it on as an experimental technique. They would like to be able to start a pregnancy without worry."

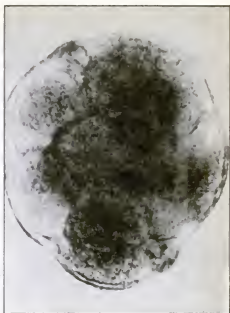
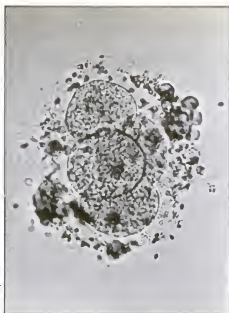
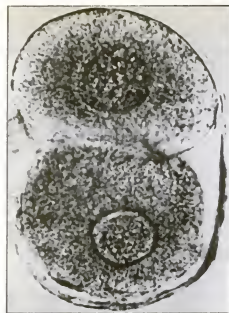
Two breakthroughs in research on animal embryos, announced in Cambridge, have convinced many biologists and clinicians that we can now embark on "preimplantation diagnosis" of genetic diseases. Both projects demonstrate that it is possible to take a few cells from a young animal embryo, analyse them and then convince the rest of the embryo, back in the uterus, to develop normally.

Ways to vet an embryo

Marilyn Monk and her colleagues at the Medical Research Council's Mammalian Development Unit have accomplished the feat in mice. They created a strain of genetically defective mice and then correctly diagnosed those embryos carrying the defective gene.

Their experimental mice carried a deficient gene for an enzyme known as HPRT. People who are deficient in this enzyme develop a severe neurological disorder called Lesch Nyhan disease. Because this gene is on the X-chromosome, the disease affects boys who inherit the defective gene on their X-chromosome. The carrier mother is protected from the disease by having another, normal, copy of the gene on her other X-chromosome.

Monk and her colleagues mated a carrier female mouse to a normal male, and collected the embryos. About a quarter of the embryos should produce no HPRT. To find them, the biologists biopsied the embryos, by removing the outer coating of the embryos (the *zona pellucida*), washing the embryos in calcium-free medium to loosen the connections between the cells, and then gently lifting away one of the eight cells. Within a day, Monk had the answer to a biochemical assay that determined the amount of the enzyme present in the biopsied cell. Back in the uterus of a mouse, the remaining seven-eighths of the embryo successfully implanted in most cases. Furthermore, her diagnoses of which embryos had only the defective gene for HPRT were right every time. So Monk has shown that it is possible to do a biochemical assay for a genetic disease by removing a single cell from an eight-cell embryo, weed out the defective ones, and get a normal



In the early days of its existence, a human embryo is just a few cells—two, four and eight (from left to right above). For people at high risk of passing on genetic diseases, a test of such an embryo's genes could be a relief

baby mouse out at the end.

But can it be done in primates, sceptics ask? Phil Summers, of the Institute of Comparative Physiology in London, has just shown that it can. He makes a small cut in the zona pellucida of an eight-day-old embryo from a marmoset monkey. A hernia of "trophoblast" cells, which will go on to develop into part of the placenta, projects from the cut. Summers snips off these cells—about a third of the 150 cells in the embryo—and grows them in the laboratory. His biopsy retrieves enough cells to enable researchers to analyse their DNA or do biochemical tests. Summers and his colleagues have transferred the biopsied embryos back into female marmosets and established six pregnancies so far. Last week, the first baby was born, a singleton of normal size.

These studies have thus established, to some people's satisfaction, that we have the embryological techniques to sample human embryos without damaging them. Molecular geneticists also think they have nearly perfected ways of analysing the DNA from just a few cells. DNA probes, suitably labelled, can reveal the presence of a particular gene, as they link to matching sequences in a person's DNA. Already, several researchers have demonstrated that they can determine the sex of an embryo by using various probes to the Y-chromosome.

At the conference, Ken Jones of the Institute of Animal Genetics at Edinburgh described a new Y-probe that is very close to the "male" gene—the so-called test-determining factor. Last month, John West and his colleagues at the University of Edinburgh and the Medical Research Council's Clinical and Population Cytogenetics Unit in Edinburgh showed that a commercially available Y-probe would also do the trick. They used the technique of *in situ* hybridisation—in which the DNA probe is added directly to the cells—to sex embryos. Their probe was labelled with a radioactive isotope, however, which takes several days to produce an answer.

Much interest focuses on the search for a labelling technique that gives a quicker result. Richard Penketh of the Hammer-smith Hospital and Janette Vandenberg of the Institute of Child Health, both in London, have just sexed an embryo with a Y-probe labelled with biotin, which produces a result in less than 24 hours.

The next stage is to find a way of bulking up specific bits of the DNA from a few cells, so that researchers could readily detect defects in single genes in a biopsied cell without having to grow it in culture. At the moment, geneticists need the DNA from about a million cells to extract enough to

diagnose a defect in a single gene. But modifications of a new technique will probably work. Last year, Randall Saiki and his colleagues from Cetus Corporation in California described a way of copying a specific stretch of DNA, called gene amplification, which looks hopeful.

Mysteries remain, but it is just a matter of time, it seems, before the technologies developed to help the infertile will be applied to fertile couples at risk of bearing children with genetic diseases. "Has anyone biopsied human embryos?" someone asked in Cambridge. Came the reply: "Not yet, but soon." □

Windows into the womb

A RELATIVELY new technique of diagnosing genetic defects in a fetus early in pregnancy is gaining ground. The World Health Organisation says that the new procedure, known as chorionic villus sampling, has been performed on 25 000 women so far. According to Bernadette Modell of the University College Hospital in London, about 10 per cent of all prenatal diagnoses in Europe now use this technique.

In chorionic villus sampling (CVS), clinicians take a sample of fetal cells that will ultimately form part of the placenta. They can test these cells for signs of Down's syndrome, for instance, as early as 10 weeks, enabling a woman to have an early abortion.

The technique thus has a big advantage over amniocentesis, the standard test for chromosomal abnormalities such as Down's, which uses cells from the amniotic fluid: amniocentesis cannot be performed until the second trimester of pregnancy. Furthermore, CVS gives a result in a few days. It takes about four weeks to obtain a result from amniocentesis, because technicians must first grow the cells in culture.

Chorionic villus sampling also provides

enough cells to enable researchers to extract the DNA to diagnose some inherited diseases such as thalassaemia, cystic fibrosis and muscular dystrophy.

The new technique is highlighting our ignorance of the early part of human pregnancy and embryonic development, says Modell. According to Yuri Verlinsky of the Illinois Masonic Medical Center in Chicago, "the accuracy of diagnosis of chromosomal abnormalities continues to be a problem". In 2685 cases, he found 26 discrepancies between diagnosis based on CVS, compared with amniocentesis or the fetus itself. Sometimes chorion cells show two different chromosomal patterns, a "mosaicism" where one set is normal and the other not. We still do not know, he said, whether the chorion is inherently more prone to such chromosomal abnormalities than the fetus.

Celia De Lozier-Blanchet, of the University Hospital in Geneva, says that such anomalies in diagnosis become increasingly important as more women between 30 and 35 seek prenatal diagnosis. "These women are at low risk genetically and we have nearly the same chance of finding an anomaly as of finding a defect." □

SCIENCE

Swansea's cleanup does more harm than good

THROUGH the Lower Swansea Valley, once an important centre for smelting and tin-plating, flows the Tawe, one of the dirtiest rivers in Wales. The river, on its course from the Black Mountains to Swansea Bay, passes through an abandoned industrial wasteland littered with tips laden with toxic metals. Like other parts of Britain's former industrial heartland, the valley is undergoing a major programme of redevelopment to make it more attractive to new industry.

Unfortunately for the public agencies working to regenerate the area, some of the attempts to repair the ravages of the 19th and 20th centuries have, paradoxically, contributed to the pollution of the Tawe.

Current high levels of trace metals found in the River Tawe have three main sources: effluent from a nickel-processing plant, the discharge from a tin-plating works and water draining from the contaminated land of the Lower Swansea Valley. Most of this water enters the main river from one of its tributaries, Nant-y-Fendrod. The contaminated land is mainly in the form of tips, which cover approximately 162 hectares of the lower valley. The tips contain appreciable concentrations of zinc, iron, cadmium, copper, lead and manganese, mostly in the surface layers. The area suffers badly from surface erosion. This problem has become more acute as a result of increased landscaping and building work since the government designated part of the valley as an Enterprise Zone in a bid to attract new employment.

Steve Bird investigated the high levels of trace metals in the River Tawe while at University College, Swansea (*Environmental Pollution*, vol 45, p 87). Bird, who now works for the Welsh Water Authority,

found that levels of trace metals in the Tawe are at their highest in spring and summer when there is less water in the river to dilute them.

Bird collected information on water quality from seven sites along the Tawe and examined the relationship between the river flow and levels of contamination. He wanted to find out which hydrological factors had most bearing on the pattern of pollution recorded at different times of the year and in different parts of the river system. The Tawe basin receives a heavy annual rainfall. Water runs off the land quickly during periods of heavy rain. The river's mean flow in winter is sometimes almost four times that in summer.

Because the soils in the river's catchment area are impermeable, dry spells can result in very low flow in the Tawe.

Bird found that the contamination of the Tawe by trace metals in general had declined since the early 1970s, but he found that levels of nickel, below the nickel-processing plant, and of iron and chromium, below the tin-plate works, remained high. There were also elevated levels of cadmium, zinc and manganese in the Nant-y-Fendrod, and in the River Tawe downstream of the point where the two rivers meet.

Total concentrations of nickel and copper are generally highest during the low flows of the summer months, when the ratio of river flow to effluent is low. There were occasional peaks of copper in winter, probably reflecting resuspension of this metal from the river bed as the stronger flow of water stirs up the sediment. Total concentrations of iron and chromium are also highest during the winter months. This is probably the result partly of resuspension

below the outfall from the tin-plate works and partly of increased inputs of particulate iron from natural sources.

Bird found a distinct peak in the total concentrations of zinc, cadmium and manganese in the spring and early summer. He says that this pattern shows "the overriding influence of the Nant-y-Fendrod on trace metal concentrations in the lower Tawe. Low-flow periods are again the worst affected at a time when dilution is reduced to a minimum".

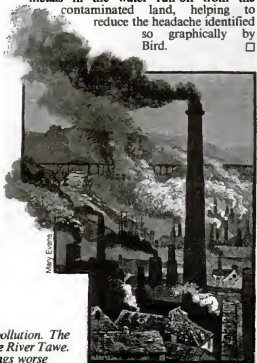
Bird also found that because most of the trace metals in the Nant-y-Fendrod were dissolved rather than bound to particles of sediment, they were more toxic to the plants and animals in the river. He concludes that some of the key factors which determine the levels of trace metals in the Tawe are flow levels and how dry the weather has been. He adds: "The discharge of metal-bearing effluents and run-off into the river at times of prolonged summer low flow will thus continue to represent a serious handicap to the development of a healthy aquatic ecosystem as well as restricting the river's aesthetic appeal."

His findings also underline the problems facing those developing a riverside park and a barrage in the area. The best time for construction and landscaping work—when the weather is dry—is also, ironically, the time when the river is least able to cope with additional pollution.

The proposals for redevelopment of the Lower Swansea Valley include the creation of a new lake, upstream of the confluence of the Tawe and the Nant-y-Fendrod. The lake is designed primarily to reduce the risk of flooding. But it has an added role. The bed of the lake is covered with crushed lime. Its presence precipitates out the metals in the water run-off from the

contaminated land, helping to reduce the headache identified so graphically by Bird. □

Mervyn Evans



Mervyn Evans

Swansea in more prosperous times. In the 19th century, there were no controls on pollution. The industry may have gone but it has left a legacy of toxic waste that continues to pollute the River Tawe.

Today's efforts to reclaim the land where the factories once stood only makes things worse.

Mutant enzymes slow the AIDS virus

RESEARCHERS are now a little closer to understanding the operation of an enzyme that is crucial to the replication of the human immunodeficiency virus (HIV). A team at the Wellcome Research Laboratories in Beckenham, Kent, has managed to alter the activity of the enzyme, reverse transcriptase, by substituting certain amino acids along its length.

Reverse transcriptase plays an important role in transcribing the RNA of the virus into double-stranded DNA. This DNA then becomes incorporated into the genome of the host cell.

The group at Wellcome concentrated on substituting amino acids in regions of the molecule which are similar in related enzymes, such as reverse transcriptase in other viruses (*Nature*, vol 327, p 716). They believed that if a sequence remained similar in several enzymes, it was likely to be important in the enzyme's action.

On this basis, they concentrated on six regions. One of these contained a sequence of amino acids which is very common in this group of enzymes, and which may be important in binding the enzyme to its RNA template. The team found that the three mutations that they introduced in this region produced interesting results. One amino acid substitution completely destroyed the activity of the reverse transcriptase, while two other changes in this region significantly reduced it.

The group then went on to see if the drugs azidothymidine (AZT) and phosphonoformic acid inhibited the mutant enzymes in the usual way. Phosphorylation plays an important part in the action of these drugs. In the case of AZT, for example, cellular enzymes phosphorylate the drug to form AZT-triphosphate. The reverse transcriptase then incorporates AZT into the growing strand of DNA,

blocking any further elongation of the molecule.

In these experiments, substituting amino acids in two further sites made the enzyme less sensitive to inhibition by AZT-triphosphate. "Thus both regions are good candidates for components of a triphosphate binding site," they say. Still other mutants were less sensitive to inhibition by phosphonoformic acid.

The significance of this work is two-fold. First, it tells scientists something about which parts of the molecule are important in the function of the enzyme and in drug binding. However, to use this kind of information in designing new drugs, it is necessary to know the three-dimensional configuration of the enzyme as well. Scientists have yet to determine this structure.

Secondly, further work along these lines will allow researchers to predict what the likelihood is of HIV mutating and so de-

veloping resistance to drugs such as AZT. The report says, "It is clear... that subtle changes in the reverse transcriptase polypeptide can result in an apparent reduction in binding affinity for... antiviral agents..."

This news may not be as depressing as it sounds. Scientists have carried out similar work to see if mutant versions of herpes viruses are less sensitive to the drug acyclovir. They found that, in general, any herpes virus that is resistant to acyclovir appears to be attenuated, or weakened.

The team is now going to put the mutant genes for reverse transcriptase into infectious virus to find out how these affect the growth of the virus. The researchers also intend to analyse some of the mutant enzymes that have impaired activity to find out how their biochemistry differs from the parent molecule. □

● See AIDS Monitor, p 20

Acid rain catches up with China

ACID RAIN is becoming a problem in China, says a team of American and Chinese researchers. The reason is the amount of coal burnt, particularly coal containing a large amount of sulphur in southern China. For example, the concentration of sulphate ions in rainwater in the city of Guiyang in southern China is about six times that in rain that falls on New York City, and more than a hundred times that in a remote area of northern Australia (*Science*, vol 236, p 1559). On the other hand, concentrations of nitrate ions are lower in much of China than in the US, consistent with the limited use of motor vehicles in China. Rain falling in Beijing, which has the highest density of cars, also has the highest levels of nitrates.

Rain in China is not as acidic as scientists

might expect because, the researchers suggest, high levels of calcium and ammonium ions neutralise some of the acidity. The calcium comes from chalky soils (in the north), small and medium-sized furnaces which lack controls on their emissions, and from building materials such as limestone and concrete. The ammonium ions probably come from human wastes used as fertiliser on agricultural land.

Together, these ions raise the pH of precipitation to about 6.5 in northern China and 4 to 5 in southern China. Without those basic ions, the researchers say, "the pH of precipitation would be about 3.5, substantially more acidic, on an annual average, than the values for the eastern United States".

The Chinese burn coal extensively to generate electricity, heat homes and cook, with only minimal controls on the emission of sulphur. The regional differences in emissions of sulphur reflect differences in concentrations of sulphate in coal, which range from 3 per cent to 5 per cent in the south, near Guiyang City, to about 1 per cent in the north, near Beijing.

Although the composition of rain in China differs from that in Europe and North America today, there are parallels with what happened in the developed countries during the coal-burning era. The researchers cite a 65-year-old analysis of rain in Tennessee between about 1915 and the early 1920s. This showed high pH, and large concentrations of sulphate and calcium ions, as in modern China. These ions apparently came from short smokestacks in the city centre, and their concentration in rain dropped with distance from the source. If China follows the lead of the US and Europe, using tall smokestacks to cure local pollution, the impact on the composition of rain will become far more widespread, the scientists warn.

Because of the absence of data on Chinese aquatic ecosystems, the researchers shy away from making any firm predictions of potential damage. However, they warn that "the extremely high deposition rates (for sulphate)... represent a major ecological concern." □

The microscopic pest with horny tastes

WHEN Wolfgang Jurecka, a Viennese dermatologist, visited the university pathology collection, he was horrified to find that many specimens showed curious signs of damage. The skin specimens, routinely fixed in formaldehyde and embedded in paraffin wax for sectioning, were pitted on their sectioned surfaces. What had previously been pristine pathology specimens were now riddled with cavities filled with loose grey granules.

Not all the specimens were damaged equally. Many were untouched, but the epidermis of skin lesions such as seborrhoeic keratoses or epidermal cysts, were positively ravaged.

Some swift detective work with a pocket lens soon uncovered the cause. A tiny six-legged larva was eating the embedded material. Jurecka's colleagues at the Vienna Museum of Natural History soon identified the culprit as *Athrenus caucasicus*, a beetle that normally lives in birds' nests. They had no trouble recognising the larva because it had also been wreaking havoc in the museum's collections of insects and furs.

Athrenus larvae have a voracious appetite for keratin and will devour horn, wool or, in the case of Jurecka's collection, the



more keratinised skin lesions. In 1915, one species, *Athrenus fasciatus*, was found in some armchairs in the White House and went on to plague furniture all over the United States, where it became known as the "furniture carpet beetle".

Reporting his observations in the current issue of the *American Journal of Dermatopathology* (vol 9, p 204), Jurecka and his colleagues from the department of dermatology at the University of Vienna Medical School say that older pathology samples are most at risk. They warn other histopathology laboratories to keep an eye on their collections. Freely applied naphthalene, they suggest, will keep the pest at bay. □

Ancient jelly plugs a gap in the fossil record

THE FOSSIL record is full of gaps because, with rare exceptions, only the hard parts of animals are preserved. Almost nothing is known of soft-bodied animals. Recently, however, George Stanley, of the University of Montana, and the West German palaeontologist, Wilhelm Sturmer, found what are probably the rarest "fossils" in the world, when they X-rayed samples of Hunsrück Slate. The slate, which dates from the Lower Devonian, 400 million years ago, is famous for its spectacular fossils, some of which show traces of tissues and soft organs.

In 1983, Stanley and Sturmer described a fossil of a comb jelly, a gelatinous animal belonging to the phylum Ctenophora. The ctenophores are tiny, bioluminescent marine animals bearing eight bands of cilia that propel them through the water. The researchers have since found a second specimen which shows more of the comb jelly's delicate structure, including the rows of cilia (comb rows) and what appear to be



A living comb jelly

gonads (*Nature*, vol 328, p 61).

The discovery should help to settle the argument about the relationship between the ctenophores and the Cnidaria (the phylum that includes the hydroids, jellyfish and sea anemones). In the past, taxonomists lumped all these animals together. But comb jellies have a more advanced anatomy and are now assigned to a separate phylum. This led to speculation on the origins of the two groups. Many thought that the ctenophores sprang early from the ancestral stock of the cnidarians. The new fossils push back the age of the ctenophores to establish them as a truly independent phylum.

Without the technique of X-radiography, the fossil would have escaped notice. X-rays pinpointed the comb jelly in the slate, allowing Stanley and Sturmer to make a preparation of the section containing the fossil. They ground the slate to a thin (2 millimetres) section and X-rayed it. The fossil, like most others in the Hunsrück Slate, is flattened. Stereoscopic radiographs "decompressed" the image to give a better idea of the animal's original shape.

The new fossil comb jelly, named *Archocyodippida hunsrueckiana*, is 23 millimetres long. It shows a possible mouth, eight comb rows, some with the plates of delicate cilia still visible. Part of one comb row bears clumps of round objects that look like the gonads of living ctenophores. Neither this specimen nor the previous one looks any different from today's.

Gelatinous animals are so delicate that even today they tend to be overlooked. Hauls from the ocean turn up few comb jellies because they disintegrate in the process. Biologists who dive in submersibles have found that deep waters are teeming with jelly animals. The new fossils hint that this was also true in the Earth's early seas.

Flamboyance is a sign of health

BIOLOGISTS have long puzzled over the peacock's tail and other flamboyant features of many male birds. Charles Darwin proposed that males evolved such traits because females choose mates on the basis of such cues. But why should females prefer males with long tails or bright feathers, when such attributes must make them more vulnerable to predators?

In 1982, William D. Hamilton and M. Zuk proposed a novel explanation. They suggested that females use the colour of plumage, the length of a tail or some other secondary sexual characteristic to assess a male's ability to resist parasites. Here "parasite" is used to include viruses, bacteria and protozoa as well as helminth worms. The brighter the male (or the longer his tail) the more resistant he is to parasites. Some of this resistance will be due to his genetic makeup, so a female can produce the healthiest offspring by mating with the most colourful male around.

Andrew Read of the University of Oxford has just produced convincing evidence in favour of this seemingly far-fetched hypothesis (*Nature*, vol 328, p 68). He began with the question: Why are the males of some species more laden with burdensome secondary sexual characteristics than others? In other words, why does the peacock have an enormous tail, while starlings are virtually unsexed? If the parasite theory is right, the species with the most flamboyant male will be those that are particularly susceptible to invasion by parasites—so making resistance to parasites a big selling point among would-be fathers.

Read set out to test this prediction rigorously. He analysed data on the parasites in the blood of thousands of songbirds from North America and Europe, and ranked the brightness on a six-point scale. As Hamilton and Zuk predicted, species with high levels of parasites tended to be brighter.

But correlations are notoriously ambiguous, and this one could be the result of a taxonomic artefact: groups of related

species might share the same traits because of their common ancestry. To avoid this problem, Read then compared the brightness of males and their load of parasites within genera. The correlation between colour and parasites was still positive.

Finally, to rule out the possibility that the correlation was due to some ecological factor, such as mating system or type of nest, he compared genera that varied in a particular ecological factor with those that did not. The results gave no sign that ecological variables could have produced the link between brightness and the prevalence of parasites in these birds. Glowing with health may be more than an expression after all.

Why atoms don't collapse

ELECTRONS have negative charge. Atomic nuclei have positive charge. So why do electrons stay "in orbit" around atomic nuclei, instead of falling in, in obedience to the dictum that opposite charges attract? The conventional answer, within the framework of quantum theory pioneered by Niels Bohr, is that electrons are not allowed to fall into atomic nuclei because each electron must retain a certain energy, called ground state energy. To fall in, it would have to radiate all its energy away, and this it cannot do. But why not?

For 70 years, no one has been able to say. Now, however, this idea has been updated and refined by Harold Puthoff, of the Institute for Advanced Studies in Austin, Texas. He says that the ground state is a dynamic balancing point, with electrons both radiating energy away and absorbing energy, from the vacuum itself.

The key to this interpretation of the stability of atoms is the idea that each cubic centimetre of space contains an enormous amount of untapped energy, called zero-point energy. This is the point from which all other energies are measured, but according to modern quantum theory it is not zero. Usually, this uniform sea of untapped

energy has no practical relevance, because it is the same everywhere; however, its presence can be shown in some experiments, such as the measurement of a force between two closely spaced metal plates (the "Casimir effect"), which is interpreted as due to imbalances in the zero-point energy caused by the presence of the plates.

In the everyday world, charged particles that are accelerated, changing either their speed or their direction, radiate electromagnetic energy. If an electron behaved like an everyday charged particle, then as it orbited around an atomic nucleus it would radiate energy and fall inwards.

According to Puthoff's calculations, made within the framework of a technique of analysis called stochastic electrodynamics, the energy is indeed radiated, exactly as it should be for a "classical" particle in the appropriate orbit. But, at the ground state the electron is also absorbing energy, from the zero-point background field, at exactly the right rate to balance its loss. The ground state of the electron in an atom is, in fact, determined by this balance point, and depends on the presence of an underlying sea of electromagnetic energy (*Physical Review D*, vol 35, p 3266).

Wetter weather linked to greenhouse effect . . .

SPLASHING our way out of one of the wettest Junes on record in Britain, and a disastrous first week at Wimbledon, the last thing many people want to hear is that it was not "just one of those things" and that the weather really is getting wetter. But that, indeed, is one of the conclusions drawn by a team of six researchers, working in the United States and England.

There have been significant increases in precipitation at mid-latitudes (including Britain and Europe), and corresponding decreases in precipitation at low latitudes (including the parts of northern Africa recently afflicted by drought) over the past 30 to 40 years. These trends are consistent with the changes in rainfall predicted by computer models of the greenhouse effect, and may be a taste of things to come.

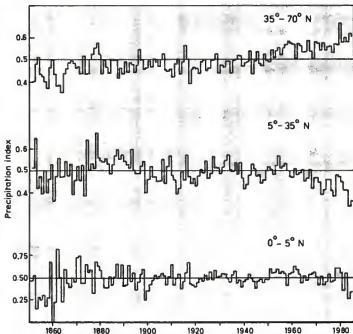
The greenhouse effect is a warming of the world brought about by a buildup of carbon dioxide in the atmosphere, as a result of human activities. So far, most concern about the greenhouse effect has focused on the temperature changes that are likely to occur over the next few decades, and which may already be happening. But major changes in both the evaporation rates of water from the surface and oceans of the globe, and in precipitation rates in different parts of the world, are also likely.

The recent Anglo-American study, reported in this week's issue of *Science* (10 July), set out to provide a baseline for investigations of these changes, by looking

Because of the difficulty of obtaining reliable weather records, the researchers concentrated on changes over the continental regions of the northern hemisphere. Among the major conclusions of their study, they find that precipitation has increased steadily in Europe since the 19th century, with an even more dramatic increase in the Soviet Union. Precipitation in the US declined from about 1880 to the 1930s, but has increased since. And, possibly most significant of all, precipitation has recently declined "drastically" in northern Africa and the Middle East.

When the data are analysed according to latitude, they show that the overall variations in the past few decades exactly match the changes predicted by computer models of rainfall patterns in the world warmed by the greenhouse effect (see figure). Precipitation hardly changes in the equatorial zone, decreases between 5° and 35° North, and increases at higher latitudes.

There is also some evidence of seasonal variations. In Europe, for example, the main increase has been in winter precipitation, with some increase in autumn and spring, while rainfall in high summer has declined slightly. Perhaps we have something to look forward to in July and August after all. □



Trends in precipitation in three zones of latitude in the northern hemisphere. The numbers on the vertical axis are "precipitation index", a parameter the team uses to define averages over different zones; what matters is the trend

at trends in precipitation since the middle of the 19th century. The team may have found signs of the greenhouse effect already at work.

... and cooler years blamed on 'mystery volcano'

MAJOR volcanic eruptions throw dust and gas, mainly sulphur dioxide, high into the stratosphere, where they linger, absorbing and blocking sunlight so that the Earth cools. The dust usually falls within a few weeks but the sulphur dioxide is converted to droplets of sulphuric acid which can remain in the stratosphere for many months. Eventually this volcanic aerosol drops out of the stratosphere and in certain, exceptional circumstances the fallout will leave a record on the surface of the Earth. The icy wastes of Antarctica provide the ideal environment to preserve such records.

Michel Legrand and Robert Delmas of the glaciology laboratory in Grenoble, France, recently found evidence of a major volcanic eruption that no one had suspected previously (*Nature*, vol 327, p 671). The French researchers analysed a core of ice 16 metres long from the East Antarctic Plateau. The ice core provides a record of 220 years of sulphuric acid fallout, including contributions from several major volcanic eruptions. The core confirms records from four other sites in Antarctica which show two significant volcanic events early in the 19th century.

Researchers believed that these events were the eruptions in Indonesia of Tambora in 1815 and Galunggung in 1822.

Legrand and Delmas suggest that the first peak of sulphuric acid fallout was not the result of the Tambora eruption because microscopic particles of volcanic glass in the core do not match material known to have been ejected by that eruption. Instead, they attribute the second peak in the sulphuric acid profile to Tambora and the earlier peak to an unknown eruption six to eight years earlier.

Legrand and Delmas's results have important implications for climatologists. Research has shown that the Earth's temperature falls by several tenths of a degree in years after a major eruption. Tambora was the largest eruption in the past few centuries. At that time, however, there were no worldwide meteorological observations so climatologists know much less about Tambora's effect on climate than they do about those of later eruptions such as Krakatau in 1883.

What records we have for the 1810s clearly indicate a temporary return to a "Little Ice Age" in the northern hemisphere, with severe winters and notoriously bad summers, after a warmer period from 1790 to 1809. In England the weather was so severe that the gardeners at Trenwanton in Cornwall, built raised beds inclined at 15 degrees to gain the full benefit of the Sun (*New Scientist*, 25 June, p 42).

The French researchers' analysis of their Antarctic ice core throws light on a problem that has puzzled climatologists since Hubert Lamb suggested in 1970 that volcanic eruptions were to blame for that cold decade. Tambora, however, erupted in the middle of the decade when temperatures in England and elsewhere had already begun to fall. The aerosol cloud from an earlier eruption could have triggered the initial cooling. The combined impact of both volcanoes would then have ensured the notoriety of the 1810s, which included "the year without a summer" in 1816.

The hunt is now on for further evidence of the unknown eruption. A team led by David Peel at the British Antarctic Survey in Cambridge is studying another 200-year core of ice, from Doleman Island off the Antarctic Peninsula. Measurements of sulphuric acid and analysis of the microscopic particles from this core may confirm that some volcano other than Tambora did erupt and may have delayed the warm-up after the Little Ice Age.

The Cornish gardeners' worthy solution to the cold climate came too late, as the second decade of the 19th century brought much better growing conditions to Europe. When they first planted their inclined beds, the splendid summer of 1826 was only a few years away.

Chris Sear

TECHNOLOGY

Materials science wins through

THREE European scientists found themselves thousands of pounds better off last week. Between them they shared a prize of £70 000 for science and technology put up by IBM. Their field of research is materials science, in particular the techniques used in constructing electronic devices. It was fitting that IBM should reward researchers in this area, because materials science is now a major element in computer and electronic research.

The ability of computer engineers to build faster machines is determined to a great extent by the dimensions of the transistors that make up a chip and the links between them. The smaller these dimensions are, the faster signals can be switched and travel from one transistor to another.

At present devices are about 2 micrometres wide, about one-fiftieth the width of a human hair. "There is nothing to prevent us cutting the distance by a factor of ten," says Praveen Chaudhari, vice-president of IBM Research in Yorktown Heights, New York, "except our control over materials science." This control becomes more important as the size of transistors shrinks and the atomic behaviour of their constituents affects the performance of the devices.

At 2 micrometres, engineers have to contend with radiation from space, migration of atoms from one material to another and interference between signals. They also have to employ very precise methods of depositing and removing materials used in making chips.

The winners of the IBM Europe Science and Technology Prize are all experts in deposition, or epitaxy as it is called.

John Lamb

They have explored three methods of depositing

layers a few atoms thick of one material on another. Elisabeth Bauser, from the Max Planck Institute for Solid State Research in Stuttgart, West Germany, won her award for her skill in growing crystal from molten materials (liquid-crystal epitaxy).

Bruce Joyce, of Philips Research Laboratories in Redhill, Surrey, is credited, with two others, with the invention, during the 1960s, of molecular-beam epitaxy. This process involves blasting a heated target held in a vacuum chamber with beams of atoms or molecules.

The third scientist, Manijeh Razeghi, from Thomson CSF's central research laboratory in France, specialises in a newer technique called metal organic chemical vapour deposition. In this case, chemical reactions take place in a mixture of gases before the products of those reactions are deposited on a target held in a vacuum. A refinement of this process (called chemical beam epitaxy), which combines elements of molecular beam epitaxy with the vapour phase technique, has been recently developed.

Both liquid phase epitaxy and molecular beam epitaxy have their limitations. Liquid phase epitaxy, widely used by chip companies, is faster than the other techniques, but it produces patchy, rough surfaces by comparison. Molecular beam epitaxy is accurate and gives a smoother finish—layers can be controlled to the depth of a single atom—but each machine can process only one wafer of chips at a time. Deposition itself takes longer than with the other methods. □

Coming to grips with the physics of transistors

IBM has devoted considerable time in trying to get a grip on the physics involved in transistor construction and operation. Its scientists at Zurich developed the electron scanning tunnelling microscope, which can measure the outlines of individual atoms on the surface of a piece of silicon. The microscope does this by measuring the current flowing through a probe from the surface of the material. Two scientists in Zurich who worked on this project won a share of last year's Nobel Prize for Physics.

More recently, IBM has come up with a technique that will help to find out more about what goes on beneath the surface of a chip. Its scientists have produced and, more importantly measured, the shortest electrical pulses yet. The blips lasted a half a picosecond, or half a trillionth of a second.

To investigate the behaviour of electrical signals within a chip, scientists need a device that can measure pulses going 10 times faster than the 30-picosecond switching times of the fastest laboratory chips.

At Yorktown Heights, researchers created short electrical pulses using a laser

beam split into two by a mirror. One beam produces an electrical current whose passage is recorded by an optical switch. The second beam, taking a longer route than the first, initiates measurement of the electrical pulse at an optical switch. IBM plans to use the technique to look at the characteristics of computer components such as transmission lines.

Two researchers at IBM's Zurich laboratories, Alex Müller and Bob Bednorz, hit the headlines for their original work on superconducting materials. They discovered that superconduction took place in certain copper oxides at much higher temperatures than ever measured before. Their discovery triggered a worldwide quest to push the temperature limit higher and higher.

High-temperature superconductors could well find a use as connectors inside computers. Superconductors could also be employed as shields against magnetic interference and to prevent crosstalk between signal carrying lines.

There are many problems to be overcome, however. Work is now focused on producing the brittle material in usable shapes, such as wire. □



IBM's European prizewinners (top to bottom): Manijeh Razeghi from France, Elisabeth Bauser from West Germany, and, from Britain, Bruce Joyce

Safety comes before new insecticide

Steve Connor

THE COMMITTEE that advises the British government on genetic engineering is next week likely to give the go-ahead for the second phase of an experiment to make a new type of biological insecticide. The experiment is to release into the environment a virus that virologists have genetically engineered to self-destruct in ultraviolet radiation. The virologists want to convince the committee that they have taken all the necessary safety precautions before they release genetically engineered viruses that cause the production of toxins which kill insect pests.

The first phase of the experiment, which the Advisory Committee on Genetic Manipulation approved last year, was to release a virus that infects caterpillars feeding on cabbages. The virus had had a piece of DNA inserted into its genetic material so that scientists from the Institute of Virology at Oxford could distinguish the virus carrying the DNA "marker" from naturally occurring viruses that did not (*New Scientist*, 16 October 1986, p 35).

The virologists, led by the director of the institute, David Bishop, wanted to find out whether the marker could be used to determine how long the virus persisted after it had killed its host, the larvae of the small mottled willow moth, *Spodoptera exigua*. The marker showed that the virus could survive for many months on cabbage leaves after the caterpillars had died.

The next step, to satisfy those people worried about the safety of such deliberate releases of genetically engineered organisms, was to make sure that the virus would self-destruct after it had killed its host caterpillars. To do this, Bishop has deleted a gene in the virus. This gene makes sure the virus's outer coat, a polyhedrin protein,



Caterpillars help to test new insecticides

D. Bishop/Institute of Virology

protects the sensitive genetic material inside the organism from ultraviolet radiation. Without the gene, the virus should not survive outside the caterpillar it infects.

"In many ways we are dealing with a black box," Bishop said last week at a conference on biotechnology organised by *Nature* magazine. "We have to be as cautious and responsible as possible." He said there was a slim chance of the virus

exchanging genetic material with other viruses of the same type, and that the self-destruct mechanism would make this even less likely.

After the Advisory Committee on Genetic Manipulation makes its decision next week, the Ministry of Agriculture, Fisheries and Food will also consider the safety implications of the experiment, because Bishop eventually wants to use the virus as a biological insecticide, and the use of insecticides comes under the ministry's control. Neither organisation is likely to stop the next phase of the experiment, however, because Bishop has taken such careful precautions to predict and to control the spread of the engineered virus.

If the second phase proves successful, and the virus does not survive outside the caterpillars, then Bishop will consider altering the genetic material of the virus still further to make the virus kill its insect host more quickly, before the caterpillars have time to damage the crop. One option is to insert the gene that produces the toxin made by a bacterium called *Bacillus thuringiensis*. The bacterium is well known for its ability to kill insects that infect crops. Last year, Belgian scientists announced that they had successfully inserted the same toxin gene from the bacterium into the genetic material of the tobacco plant. The altered plant survived heavy infestations of caterpillars.

Eventually, Bishop would like to try out his techniques on viruses that attack caterpillars of the pine beauty moth, *Panolis flammea*. The larvae of the moth destroy hundreds of hectares of forests in Scotland, and the Forestry Commission wants to see if there is an alternative to spraying the trees with chemical insecticides. □

Battle over screen technology takes a new twist

A JAPANESE company is trying to sell British electronics firms a range of liquid-crystal displays that incorporate techniques that the Ministry of Defence's Royal Signals and Radar Research Establishment claims to have patented. The improved LCDs sold by Toshiba use a technique called supertwist to improve the contrast of displays and the angles at which they can be viewed.

The Ministry of Defence maintains it has patents on supertwist and has already fired the opening shots in a battle to claim licence fees from companies using the technology (*New Scientist* 5 March 1987, p 16). To date none of the Japanese and European firms approached by the Ministry of Defence has agreed to pay up, but the ministry is hopeful of convincing them that they need a licence. Toshiba admits it has deliberately avoided referring to its displays as supertwist: they are known as super TN.

The ministry's British patent covers the design of a liquid-crystal cell and the composition of the crystal inside it. Toshiba denies that it is infringing any patents. "For someone to claim they have a patent over the idea of supertwisting is nonsense," says Phillip Taylor, British sales manager for Toshiba's electron tube and device division.

Toshiba maintains that like other companies producing this type of liquid-crystal display, it is merely "doping" readily available materials and improving the engineering tolerances to get the all-important extra twist.

Each light point in a traditional liquid-crystal display consists of a twisted column of liquid-crystal that can be made to reflect or transmit light. The column lies between glass plates with grooves scratched in them. The grooves impart a 90 degree twist to the liquid-crystal, which prevents it from reflecting light. Each column is switched on by applying a voltage to it which untwists the column.

Individual columns or picture elements are selected by passing a voltage through a grid. The picture elements are activated by sending pulses line by line down the grid. The trouble is that as the number of lines increases, the smaller the total voltage that reaches each liquid-crystal column, and hence the smaller the difference between the on and off voltages. The upshot is crystals that are half on most of the time, reducing the contrast and the angle at which a display can be looked at.

The Royal Signals and Rotor Research Establishment came up with the idea of twisting the columns of crystal more so that their light-reflecting properties were more

responsive to voltage changes. Twists of 270 degrees were achieved by adding new ingredients to the liquid-crystals and by making the cells more accurately.

For the moment, supertwist LCDs are favoured by portable computer companies because LCDs are easily run off batteries. But the big market for LCD is in television. Within a few years many portable colour television sets will display images composed of tiny droplets of transparent liquid-crystal rather than glowing phosphor dots. Because they need a bulky electron gun, liquid-crystal display sets will be a few centimetres thick.

But these screens will not be supertwist. To create TV images, LCDs must react much faster than the multiplexed computer screens. Each element must have its own transistor switch. In Japan last year, 3 million flat screen black-and-white sets were manufactured.

Smaller 7.5-centimetre colour sets are already on the market, and the screen size will grow as manufacturers master the techniques of making large liquid-crystal displays. The demand from computer and colour television factories will be a major factor in increasing sales of liquid-crystal displays from \$1 billion to \$1.5 billion annually over the next three years, according to Toshiba. □

Ministry sets standards for military software

COMPANIES wanting to sell computers to the Ministry of Defence for fitting into everything from ships to tanks must now adopt a common language for their software. It is called Ada, which is now the standard programming language for computers inside larger defence machines, known as embedded computer systems, throughout NATO. Britain adopted Ada last week.

"Military computers of the Allied countries in NATO need to be able to talk to each other," said a spokesman from the ministry. "NATO has gone for Ada and as from 1 July we have gone for Ada."

Forcing companies to go for one standard computer language will allow allied armed forces to work together. It should also cut down the heavy investment they need to maintain and update software.

Programming languages enable programmers to make a computer do what they want. Ada was chosen as the one that is most suitable for controlling the many complicated tasks carried out by microprocessors on aircraft, ships and other military systems.

On fighter aircraft, for example, radar screens, engine actuators and missile systems must all be controlled and coordinated. The cost of developing and maintaining the software to do this is escalating, and the industry is worried about the shortage of design engineers to develop and test the software, and to adapt it as the operational requirements of military vehicles change.

In the US, the Electronic Industries Association claims that, by 1995, the Pentagon will spend \$42.45 billion a year on embedded systems. Of that, \$35.6 billion will be on software, and for the past three years the Department of Defense there has asked contractors to use only Ada. The market in Europe is expected to be worth half as much again.

The need for good software is increasing. Modern fighter aircraft require between 0.5 and 1 million megabytes of stored computer information, up to 16 million times more than the 64 kilobytes of control software 10 years ago. Taking in information from many microprocessors and responding to it in real time is a tall order.

According to Elwyn Wareham of Systems Designers, a leading supplier of Ada software, a standard language will

Mary Fagan

allow software engineers to move from project to project. A software designer would no longer have to be retrained to adapt to another programming language.

The most important piece of software is the compiler, which translates the language into basic instructions that the microprocessor understands. Compilers need to go through rigorous "validation", showing that they can translate thousands of different programs for a given microprocessor before they are approved for use.

Although there are about a hundred validated Ada compilers available, they have problems. Wareham says that today's approach is to have one program running on one microprocessor. Now Systems Designers is working with an American company, Digital Equipment Corporation, on a compiler that will help to control the interaction between different microprocessors doing different jobs. This means that the designer of aircraft control systems, for example, can concentrate on the overall task, and can postpone a decision on which microprocessor does which job. □

Treadmill spawns a fishy tale



Graham's treadmill will help to relate a fish's swimming performance to oxygen supply

SCIENTISTS at the Scripps Institution of Oceanography in California have built a treadmill for large, fast-swimming fish. "A lot is known about the physiology and performance of salmon and trout, but not of larger fish," Jeffrey Graham, a physiologist from Scripps, said last week. "With this equipment we will be able to study fish up to a metre in length." Ultimately, the research should also help fishermen to keep track of fish such as tuna, Graham said.

The fish are placed in a viewing area in a closed, oval-shaped tunnel about 7 metres long. Water, which can be warm or cool depending on the experiment, is propelled through the tunnel at up to 2 metres a

second, a rate several times faster than most fish swim. The fish can be made to work hard by changing how fast the water is going and how much oxygen is mixed in.

The relationship between swimming performance and oxygen supply is of particular interest to the researchers. Oxygen consumption, body temperature, blood flow, muscle activity and heartbeat can all be measured.

The portable equipment can be used at different locations or taken to sea. For 10 days from tomorrow (Friday), the treadmill will be used on board the research vessel Sproul, 150 kilometres off San Diego, to test Albacore tuna, the blue shark and the mako. □

Study in Hawaii links broadcasts to cancer

RESEARCHERS in Hawaii have found a suspicious correlation between cancer rates and the locations of radio and television broadcast towers in Honolulu. Cancer rates among men were significantly higher in eight out of nine census areas containing broadcast towers than in similar areas without broadcast towers. The study says nothing about the causes of the cancers, but it does indicate the need for further research, says Bruce Anderson of the Hawaiian Department of Health.

Anderson describes the study that he and fellow epidemiologist, Alden Henderson, performed for the Honolulu city council as "quick and dirty". They submitted a report about a year ago, and it has received little

attention until now. He warns that their analysis did not consider variables known to affect cancer incidence, including levels of exposure, length of residence, or lifestyle factors such as smoking, occupation and diet.

Overall, cancer rates in census areas with towers were 1.45 times higher than expected for men and 1.27 times higher than expected for women. Averaged over all areas, the differences were statistically significant, Anderson says. Differences in rates of leukaemia—the type of cancer most often thought to correlate with exposure to some types of electromagnetic radiation—were not statistically significant, however.

Unlike other American cities, Honolulu has broadcast towers in densely populated urban areas. Honolulu's planning rules discourage building towers on hills around the city, but allow them in urban areas. This has led to high radio-wave exposures for some residents. In a study in 1984, the federal government's Environmental Protection Agency found radio-frequency exposures above national standards in some areas of Honolulu.

Some residents have expressed concern about interference with electronic equipment, as well as potential health problems. However, there has not been enough pressure to stimulate the follow-up study which Anderson suggests. □



On guard.

The stance we're taking is to generate interest in Britain's ancient woodlands, because they're under threat.

The New Forest, Windsor Great Park and the Caledonian Pine woods are prime examples of ancient wood pastures, but the most traditional form of ancient woods is what you see here.

The coppice.

Woodland thrived in medieval times, but since 1945 10% of the remaining 500,000 ha. of ancient woodland has been cut down.

The Nature Conservancy Council believes that destruction for any purpose must now stop, and our ancient woods should be properly managed. Indeed, the NCC has gone so far as to list all ancient woods, county by county, to provide a national inventory.

In support, Esso has joined with the NCC to launch the Ancient Woodlands Project.

Our sponsorship is enabling the NCC to produce a series of illustrated regional books designed to encourage interest in local woodlands - describing their history, uses and wildlife, with lists of woods to visit.

A further national volume will incorporate a management handbook for professional foresters and weekend conservationists alike. Guidance will be given on what should and should not be done with ancient woods.

You may like to know that the NCC's inventory has already been accepted as part of the Forestry Commission's Broadleaves Policy. Good news, indeed. In this European Year of the Environment, however, we urge you to be 'on guard.'



Quality at work for Britain.

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Welcome to the global old folks' home

The world is feeding five billion people—and still has food to spare. Now the fear is that we are growing too old. But cheer up, the demographers have been wrong before

Fred Pearce

THIS SATURDAY is "the day of the five billion". Give or take a few weeks, it is the day when the world's population passes this figure. Or so says the United Nations Fund for Population Activities (UNFPA), which adds that 11 July "will be a day for the world to pause and contemplate a future in which population will eventually reach 10.2 billion by the end of the 21st century".

This sort of imprecise precision gives demography a bad name. Nobody knows within a few hundred million how many people there are in the world, still less what the future holds. Until a recent census, demographers' guesses about the true population of China varied by 50 million. The Nigerian government says its capital, Lagos, has a population of 1.2 million, while the UN estimates 2.8 million. Local researchers put it at up to 5 million.

In the arid fringes of the Sahara, where the growth rate of population is reckoned to be the highest in the world, many countries have never conducted comprehensive censuses. Recent estimates of the population of Ethiopia have varied from 33 million to 44 million. John Caldwell from the Australian National University, one of the world's leading demographers, says data on birth and death rates from these countries show "little more than demographic analysts seeking safety in numbers".

In the southern states of the US, nobody imagines that the "wetbacks", illegal immigrants from Mexico, fill out census forms. In Britain, demographers estimate that 200 000 people were missed off the last census, including 1 in 40 residents of inner London.

Since we do not know how many people there are in the world today, the UNFPA's predictions for the future are even less likely to be reliable. The fund says there will be 6 billion people in 1999, 8 billion in 2022 and a new plateau of 10.2 billion will be reached around the end of the next century. There is no compelling reason why the world's population should stop growing then, or ever. But the UN assumes that the poorer developing world, where two-thirds of the global growth in population is now concentrated, will follow the demographic path trodden by the developed world, where growth has now more or less ceased.

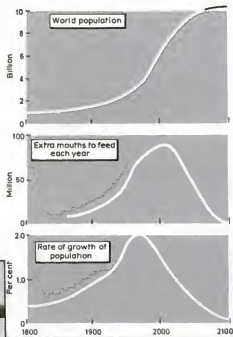
The argument is that, as countries prosper, parents need fewer children. Offspring are no longer an economic asset, working the fields or tending their elderly parents, but more of a liability: they need schooling and make it difficult for both parents to work away from home. Pessimists, such as Lester Brown at the World-watch Institute in Washington, however, see little chance of the poor nations of the world making the breakthrough to the kind of prosperity that would encourage

peasants in town or country to limit the size of their families.

The UNFPA expects the population of countries in Africa, which is at a much earlier stage of development than any other continent, to grow massively before settling down. The pessimists fear that Africa may be overtaken by economic or environmental catastrophe first. They doubt that Nigeria, for instance, can sustain the quintupling of population to more than 500 million people that the UNFPA predicts for it by the year 2050.

One of the greatest demographic coincidences of recent years was the date, 1973, when the rate of growth of the world's population peaked and began to subside from its high of more than 2 per cent per year. For some reason, a few months before the world's economy was thrown out of gear by the huge rises in oil prices, the couples of the world decided to start having fewer babies. There can have been no connection between the two events, unless the sudden slowdown in the world growth that followed the rise in oil prices persuaded demographers to

Counting the world's population is not easy. Nor is interpretation. The diagram shows three versions of the "problem". The annual growth rate is falling, but numbers are rising faster than ever



revise downwards their assumptions about population growth. But it makes life harder for people trying to establish causal links between demographic and economic changes.

The decline in the percentage rate of growth of the world's population does not, for the moment, halt the escalating increase in the numbers of people in the world. It took 13 years, from 1974 to 1987, to add a billion people to the global total. It will take 12 years to spawn the next billion and 11 for the billion after, according to the UNFPA's graphs. Only after that, in the second decade of the next century, will succeeding billions arrive more slowly, says the fund.

But 1973 was, nevertheless, a real turning point. At that moment, there were 64 children under 15 for every adult of working age. Today that number is down to 54, and the UNFPA believes it will fall to 38 by 2025.

Does all this matter? Some people see more heads as a boon, some see them as a burden. They come with mouths that must be fed, but also with brains to think and hands to work. More children undoubtedly pose short-term problems for nations. But by the age of five they may be in the fields, contributing to long-term wealth.

The balance of the argument rests on whether you believe in a "law of diminishing returns", as more of the world's resources are exhausted, or in "economies of scale", as more people exploit the resources more efficiently (*New Scientist*, 9 August 1984, p 12). Pessimists stress the limits to how much

could develop and food shortages would not turn to famine. Peter Bauer, a professor of economics at the London School of Economics, takes a similar view.

At the UN's population conference in Mexico City in 1984, the delegation from the US, galvanised by President Reagan's opposition to abortion, argued that even rapid population growth was not itself undesirable. Market forces, if given free rein, should ensure that economic development kept pace. At a previous population conference, in Bucharest in 1974, the political line-up was quite different. Then, the US backed curbs on population growth, while the socialists claimed that curbs would hold back developing nations. Iran and some other Muslim nations still believe that a larger population is beneficial to economic growth, but they are out of fashion except, ironically, in the US.

Whatever the swings of fashion, the more apocalyptic visions of the future for a more crowded world, outlined in the early 1970s by groups such as the Club of Rome, have not stood the test of time. Contrary to the club's expectations, prices of commodities from oil to grain have slumped. The world is awash with excess food, even if the poor do not have the money to buy it. The green revolution in Asia has left even fast-growing nations such as India and Indonesia with spare grain and rice.

Nobody talks any more of an imminent energy crisis. And the development of "new materials" such as ceramics, which

come from plentiful raw materials, makes nonsense of past concerns about the disappearance of basic raw materials for industry.

Last year, the US's National Research Council attempted to establish middle ground in the debate. It said there was no "necessary relation" between population growth and the exhaustion of resources. Increased scarcity of resources would be likely to stimulate technological advance. The dangers from fast population growth were largely those of the failure of government institutions to respond and adapt.

One member of the council's committee, Samuel Preston, who is also director of the Population Studies Center at the University of Pennsylvania, says: "Rapid population growth in most

times and places is a relatively minor factor in reducing per capita income and other indicators of welfare." Despite the doom-mongering of the past decade, Preston observes, "we haven't gone to hell in a handbasket".

Hell, according to a new brand of worriers, may come in another form. Declining birth rates, it now seems, are as bad for nations as rising birth rates. *Newsweek*, the American magazine, devoted a cover feature last December to "Europe's Baby Bust" and the prospects of a "long, stark demographic winter" for the continent.

The concern arises because the birth rate in many European countries is now below that needed to maintain populations. In West Germany, the average woman is estimated to have 1.3 children, well below the replacement level which, allowing for childhood deaths, is 2.1 per woman. The German population fell by 400 000 between 1980 and 1985. The UNFPA says that, even if the fertility rate there slowly returns to the replacement level, the population will fall by a

PEOPLE ARE TO IRELAND AS CHAMPAGNE IS TO FRANCE.



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REPUBLIC OF IRELAND



In Ireland, a
booming population
is seen as good
news...

food can be grown on the land. Optimists say the green revolution suggests that there are no such limits.

Propaganda flies in both directions, not least because the science becomes confused by moral arguments about birth control. China has adopted draconian policies to hold down its population to close to the current level of a billion. But Kenya seems relatively untroubled by the fastest-growing population in the world, with 4 per cent more people each year. The country survived intact the horrendous drought that took neighbouring Ethiopia onto the world's front pages in 1984. By most accounts, the economy of Kenya is doing well.

Right-wing economists in the US, headed by Julian Simon from the Heritage Foundation, say that population growth is, at any rate in the long term, a good thing. They point out that in, say, the remote areas of Sudan, a larger population would enable local food markets to develop and make the construction of roads and railways worthwhile. Local economies

further four million within the next four decades or so.

According to the EEC, a drop in the birth rate within the community of 30 per cent, since a peak in 1965, heralds a fall in the population of the 12 nations from 320 million today to less than 300 million by the middle of the next century. Only Catholic Ireland is currently producing enough babies to maintain its population.

The trend worries people on two accounts. First, it suggests that Europe may have a diminished place in the world. The EEC puts it this way: "The population of [the EEC] as a proportion of the world population is in the process of being halved during the second half of the 20th century and will be further halved in the first quarter of the 21st century." Put another way, in 1950 Europe's population, including the Soviet Union, was double that of Africa; by 2050, according to the UNFPA, it will be only a third that of Africa. In 1984, the European Parliament passed a resolution stating its belief that "population trends in Europe will have a decisive effect on the development of Europe and will determine the significance of the role which Europe will play in the world in future decades".

Secondly, nobody likes the idea of an ageing continent. Europe, says one French demographer, Alfred Sauvy, could "become one enormous old people's home". According to EEC officials: "Falling birthrates will result in a reduction in the working population after the year 2000... It is essential that Europe maintain a minimum of demographic vitality. It needs a permanent pool of large numbers of young people." In Europe, by the year 2025, a quarter of the population will be over 60. They could become an important political force. Already the US has spawned an active pressure group called the Gray Panthers.

The Japanese, who have the longest life expectancy in the world at 77 years, have similar worries. Their fertility rate is down to 1.7 and falling fast. A study produced by the Population Research Institute at Nihon University for the International Labour Organisation says that the country's ageing population will cause an eightfold increase in the cost of health care between 1978 and 2010 and a thirteenfold rise in pension benefits by 2025.

The study concludes that: "The growth of Japan's economy is likely to slow down, approaching an annual rate of 1 or even 0 per cent in the first quarter of the next century owing to a decrease in the growth rate of the labour force and to a change in its quality due to its age-compositional variation."

Ageing is now an international phenomenon that stretches beyond the developed nations into the Third World. The countries putting the most severe brakes on births now will be the ones with the worst problems of ageing in the next century. And that puts China top of the list. The country has become used to having a gerontocracy for its political elite, but will it be able to cope with them on the farm as well?

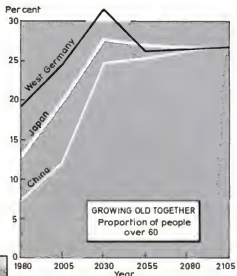
China has a fifth of the world's population. Its drive to restrict each family, first to two children and now to one child, has been the dominant

cause of the slowdown in growth in the world's population in the past decade. A range of financial incentives and penalties, coupled with China's formidable social organisation, has already cut the annual growth in numbers of people from 2.2 per cent to 1.2 per cent.

The effort is applauded by the UNFPA. This is despite unease within the fund about whether China meets the fund's call that nations should promote "free and responsible" family planning and avoid coercion. Such concerns were a prime reason why the US withdrew its grant from the UNFPA in 1985. Now a recent study by Susan Greenhalgh and John Bongarts from the Population Council in New York raises serious doubts about China's policies. They are socially and ethically dubious, they say, and one consequence has been an apparent epidemic of female infanticide. Current birth statistics show 112 male births recorded for every 100 females among third and subsequent children in a family.

The abrupt slamming on of the brakes on births will cause a surge in the number of people over 65 in a country still ill equipped to cope with them. The old made up just 4 per cent

of China's population a decade ago. By 2025, they could account for 16 per cent. Soon afterwards, China could have the oldest population in the world, with



China has put a sharp brake on births. The result, next century, will be many more old people. After that? The UNFPA predicts a striking similarity between nations



more than 150 million people over the age of 75 by the middle of the next century.

Some European countries are attempting to revive their birth rates by encouraging larger families. Most notoriously, Romania's president, Nicolae Ceausescu, has created "birth squads", who visit women in their homes and ask them why they are not having children. It is part of a state crackdown on abortions. Last year, Ceausescu said: "The fetus is the socialist property of the entire society. Giving birth is a patriotic duty which is decisive for the fate of the country."

Other countries offer more carrot and less stick, with tax incentives and more child care. East Germany has raised the number of births by a third by offering a year off work for mothers with more than two children and making it illegal to dismiss from work women with children under three years old.

The fertility rate in Britain, at 1.8, is higher than most countries in western and northern Europe. This seems to be linked to the country's poverty compared with its neighbours. But there may be more to it. Mike Murphy, a research fellow with the Centre for Economic Policy Research in London, has found an intriguing "council house effect". He told a recent meeting at the centre: "Local authority allocation procedures [which give priority to families with young children] encourage some to bring forward childbearing... the local authority sector [of housing] has a substantially higher proportion of larger families." The effect appears to be independent of social class.

Britain's relatively high birth rate means that the country's population will probably continue rising slowly until around the turn of the century, and the proportion of those over 65 will remain stable. Pat Thane, a British social historian, believes that: "During the next 20 years, Britain will experience greater demographic stability than at any time during this century." But, says the government, "after the turn of the century numbers [of pensioners] will rise rapidly as those born during the baby boom of the 1950s and early 1960s reach retirement age."

Currently, 15 per cent of the British population is over 65. The UNFPA says it will rise only slightly to 15.2 per cent by 2000, but leap to 18.3 per cent by 2025. Other demographers predicts that it will reach 20 per cent. A large part of this increase will be among people over 75, especially men. Among the working population there will also be a shift, with many more over 40.

The presumption behind all this concern about an ageing population is that the old are a burden on society. But how true is this? Thane says that "future generations growing up in wealthier and healthier environments, may stay fit and independent to later ages." Assuming this optimistic prognosis for Britain to be true, the new class of "fit young elderly" would be most useful, "providing services for the very old, including much that would otherwise fall upon the social and medical services". Dad's Army could be transformed into Dad's nursing corps.

Tomorrow's elderly are already with us and their demographic future is reasonably predictable. But projections for birth rates in countries such as Britain are the wildest speculation. False predictions can prove expensive. In the 1960s, plans were laid in Britain for the construction of a ring of huge new towns round London—just as the "baby boom" turned into the "baby bust" in 1965. We are left with Milton Keynes and a legacy of local government reorganisation that nobody would consider necessary today.

The past decade has seen a drop of 30 per cent in the number of pupils in primary schools in Britain. Schools are being shut in large numbers on the assumption that the birth rate is not about to rise. Yet many demographers predict that that is precisely what will happen.

One of these is Bill Brass, the president of the International Union for the Scientific Study of Population. He criticises current methods of measuring fertility. The standard esti-

mate, which puts the numbers of births per woman in Britain today at 1.8, is based entirely on the assumption that women are continuing to have babies at the same ages as in the past. But that is not how the modern world is. The extent to which the recent decrease in fertility "is due to postponement of childbearing can only be determined with certainty in the future," says Brass.

Brass, who is also director of the Centre for Population Studies at the London School of Hygiene and Tropical Medicine, suggests that more certainty can be gained from investigating real family sizes. A measure based on how many women with one baby have a second, and how many with a second have a third, finds a much smaller decline in fertility over recent years. Brass believes that this measure filters out the temporary decline in birth rates caused by women choosing to have babies later than before. There are already signs of a rising birth rate among the over-30s. Brass has discovered that, since 1975, more couples are choosing to have two children than one.

Moreover, the National Child Development Study, which has followed women born in 1958, finds that "if family size expectations are fulfilled there will be a substantial increase in births in the 1990s as women in the reproductive period increase in numbers, and changes in the timing of births stabilise". Stand by for a crash school-building programme after the next general election.

In the 1930s, demographers throughout Europe hoisted warning cones about declining populations, after the cataclysmic losses of the First World War were followed by a falling birth rate. In Britain, one demographer, Enid Charles, argued that falling birth rates could leave the population of England and Wales at around 10 million by early in the 21st century. Demographers have good cause to remain humble about their science. □



Who says the old are a burden?

The making of star wars

Twenty-five years ago today, the US detonated a nuclear bomb in space. The explosion marked the beginning of secret work on the Strategic Defense Initiative

David Baker

OPPONENTS of the star wars programme believe that they will be able to overturn it when President Reagan leaves the White House in little over 18 months. With a new president installed, and suitable lobbying, they say that the Strategic Defense Initiative (SDI) will be defeated. Since the programme was officially announced in March 1983, newspapers and politicians have linked the SDI to the previously unsuccessful attempt to build a ballistic missile screen in the 1970s, called Safeguard. This system relied on two different types of missile to intercept incoming warheads. As a defence system it was moderately successful. The cost of Safeguard, though, was high. And the programme brought the US into open confrontation with the Soviet Union's arms negotiators, a precedent, some say, for cancelling its apparent successor—the SDI.

In the real world, however, the SDI is not related to the Safeguard antiballistic missile (ABM) programme. Nor is it threatened by sudden political shifts. The SDI will not fall because of changes in the White House, and it is unlikely to be defeated by linking it with previous attempts to build a missile screen. The Safeguard project lacked two essential ingredients that SDI work built upon: political strength and an organisation to make it work. The Safeguard project was merely a by-product of overzealous generals looking for a way to protect rocket sites. It had a technical base but lacked

political support and a focused structure with committed scientists. The SDI programme has all three essential ingredients for wide, bipartisan support irrespective of who runs the White House. It became known as the SDI when Reagan found it politically necessary to gather previously secret work under one umbrella. The name could change again. The programme probably will not.

The road to Safeguard began in Hitler's Germany when V-2 rockets successfully blitzed London, Antwerp and Paris during 1944-45. No country develops a weapon without working on a deterrent, if only to find out how the enemy might try to stop the weapon. What the Germans learnt in trying to devise a means of shooting down a ballistic rocket



In 1952, the US conducted its first test on a Hydrogen bomb on Marshall Island in the Pacific. It was the consummation of Edward Teller's desire to build the H-bomb, and a step towards the SDI



Propaganda



Yuchio Sasaki/UNA photo

The type of bomb—the Fat Man—that devastated Hiroshima and Nagasaki. Hiroshima was destroyed at about 0815 on 6 August 1945

THREWOOD

was that it takes a weapon many times faster and more reliable than the missile itself. When the missile is at the limits of technology, the counter-weapon is beyond reach. At that point the missile is unstoppable and, politically at least, is considered to be the ultimate deterrent—but only until technology moves on and opens a gap.

At the same time as the pioneers of German rockets were testing the V-2, they were examining designs for a counter-weapon. This research led eventually to work on ABMs in the US during the 1960s. The treaty between the US and the USSR of 1972 banned such weapons and put an end to work on anti-ballistic missiles. The work on Safeguard, though, served only to veil the escalating developments towards the SDI. These developments had their origins in an exodus of physicists from Germany in the 1930s, a group which included Edward Teller, a Hungarian.

Teller was one of an elite few that J. Robert Oppenheimer recruited to build the world's first atomic bomb. Teller was also an advocate of the potentially more powerful fusion device, the hydrogen bomb. Typically, an atom bomb has about 2000 times the destructive force of the biggest

conventional bomb ever built. Teller wanted to create a fusion device potentially 2000 times more destructive than the atom bomb. He failed to convince Oppenheimer to go down that route. Few scientists wanted more than the minimum destructive force necessary to defeat Hitler as quickly as possible. Many of the scientists were Jews and had witnessed during their last months in Germany the excesses of the Nazi regime. It is a myth that they were hired scientists seduced by dollars and big research facilities.

Teller persisted with his ideas even as the US tested the first atom bomb at Alamogordo in New Mexico in July 1945. When the scientists learnt six weeks later of the effects of atom bombs on Hiroshima and Nagasaki, most were alarmed at the prospect of an even more devastating weapon. In secret, a raging debate split Oppenheimer's supporters from the more radical minority group led by Teller. Teller's group accused Oppenheimer and his supporters of hindering research vital for national security. As head of the Los Alamos weapons laboratory responsible for research on the atom bomb, Oppenheimer endorsed the Atomic Energy Commission in its statement "that by one means or another the development of the [fusion] weapons can be avoided".

Oppenheimer was silenced with accusations of anti-American behaviour and the intent to conspire against the US by working for the Soviet Union. When asked about Oppenheimer's suitability for keeping his top-security status, Teller testified at hearings arranged by Senator Joe McCarthy to purge communist sympathisers, that "if it is a question of wisdom and judgment... then I would say one would be wiser not to grant clearance". Oppenheimer was discredited, his clearance removed and the rift between the factions opened wide. By this time Teller had got his way. In January 1950, President Truman authorised full-speed development of the fusion bomb, a thermonuclear device where isotopes of hydrogen (deuterium and tritium) fuse to form a heavier element, releasing huge amounts of energy. ▶



Launch of a device in 1984 to shatter weapons as they re-enter the atmosphere



Research into fusion weapons was important for understanding the behaviour of high-energy particles, and this work later proved invaluable for some aspects of the SDI. The hydrogen bomb was much more powerful than the A-bomb. In the first test, called Operation Mike, in 1952, an H-bomb completely destroyed a Pacific island with a fireball 5 kilometres across.

Teller scored a second time when he convinced the authorities to build him a special research laboratory far from the dissenting physicists at Los Alamos. This was the Lawrence Livermore Laboratory east of San Francisco, which Teller helped to set up in 1951-52. Elsewhere, his former colleagues shunned him with accusations of bringing about the downfall of a great scientist; Oppenheimer drew considerable sympathy, and his peers hailed him as having made unprecedented contributions to nuclear physics.

Teller, meanwhile, got to work on realising his next dream. He wanted nuclear weapons to stop ballistic missiles in flight.

During the 1950s, Teller worked in secret to build political acceptance for his radical ideas. He forged a route to President Eisenhower via a widening circle of associates in Washington DC. Teller warned of an impending threat from the Soviet Union, and said that the USSR could build a shield against nuclear missiles and escape retribution from a pre-emptive strike by the US. Washington's belief in this threat created the environment where the government spent millions of dollars on Safeguard. At the same time, though, Teller was creating the environment where work crucial to the SDI could flourish. Teller was now developing the three sure legs on which his work would move forward: military interest, political will and a government research facility (the Lawrence Livermore Laboratory) staffed by young turks and ardent hawks.

Teller left Livermore in 1960 to concentrate on mobilising a clandestine national effort which would prepare the way for a radical defence strategy. He retained an office at Lawrence Livermore, however, and stayed on as senior consultant, advising the new director and his staff on future projects. It was a different environment to Los Alamos. There, the legacy of Oppenheimer bred restraint and a more conservative attitude to strident initiatives. The staff played no role in politics and wished for none.

Having staffed the Livermore laboratory with physicists sympathetic to the development of exotic nuclear devices and antimissile systems, Teller moved to secure a commitment in principle from the Pentagon. That was easy in the defence climate of the early 1960s. The big intercontinental ballistic missile (ICBM) projects were well under way. The US believed that the Soviet Union was churning out several thousand strategic weapons, and the Joint Chiefs of Staff were encouraging a stronger commitment to national defence. Teller tried, in vain though, to dislodge resistance from the ageing President Eisenhower, who was cautious about a



US Army/AFOS

Preparing a site (above) to receive antiballistic missiles (such as those shown in position below). An artist's view (right) of a space-based laser system



US Army/AFOS



Soyuz

runaway arms race.

When John Kennedy came to power in 1961, the Secretary of the Air Force issued a statement affirming that "military supremacy in space is as essential to our security as military supremacy at altitudes near Earth". Within a year, Teller's campaign for research into nuclear antimissile systems led to Operation Starfish, a realistic test with atomic weapons outside the atmosphere. It reached its memorable climax on 9 July 1962, when a missile launched from Johnston Atoll in the Pacific sent a nuclear bomb into space. When it exploded the sky turned bright pink and orange: radiation, far more lethal over greater distances than would occur with a low altitude, atmospheric test, damaged or destroyed scores of satellites.

General Thomas S. Power, commander in chief of the Strategic Air Command, was an ardent enthusiast, claiming "absolute superiority in space is essential to the future welfare and security of the free world", and going on to assert "we must achieve a strategic space capability". But the test in space brought criticism from many countries, a vigorous rebuff from the Soviet Union and rumblings in the United Nations that drove the hawks underground. From then on, papers were classified, tests were screened for their public relations impact, and a new secrecy veiled the programme.

Teller had gathered together a group of people in defence matters and influential advocates from the intelligence community. He needed to find a catalyst for radical shifts in thinking about missile defence: he found a supporter in General George J. Keegan Jr, head of US Air Force Intelligence.

Coincidentally, Keegan had begun to assemble a fat dossier on research on high-energy physics in the USSR. Since the mid-1940s and the end of the war with Nazi Germany, US intelligence had closely monitored Soviet developments in atomic energy. Much of the work carried out by the Russians in support of their nuclear power programme was seen by observers to have strong relevance to

research in to particle beams (one of the main technologies of the SDI).

Crudely, a particle beam is a directed flow of energetic particles such as electrons, protons or ions. In theory, beams can achieve enormous energy, and Soviet scientists and engineers wanted to develop the technology to take advantage of the theory. Keegan's men collected presentations and papers from seminars and conferences in the West, putting together a remarkable story about Soviet capabilities. They penetrated Soviet scientific circles and assembled evidence about the depth of Russian knowledge.

To their dismay, they found that Klaus Fuchs, a British scientist, had not only leaked secrets about the US's bomb programme since 1943, but he had also provided potentially more valuable secrets to the USSR for several years. In secret, Britain had carried out high-energy research towards the end of the Second World War separate from a "cooperative" programme with the US on the atom bomb. Fuchs had inside knowledge of work on particle beams going on in Britain with potential for a new kind of weapon. In the pressures of war, this research never received the funds necessary to build working prototypes.

Fuchs handed the information to Andrei Sakharov, a Soviet physicist. Sakharov used the information to plan a research base at Semipalatinsk. The base's function was to explore the possibility of building fusion devices to generate enormous quantities of electrical power. To the southwest lay the Sary Shagan test complex for antiballistic missiles. By the early 1960s, the Soviets were constructing underground nuclear test chambers at Sary Shagan where they could carefully monitor bombs in controlled situations. Although Semipalatinsk was funded ostensibly to support work on the energy programme, what Soviet physicists discovered confirmed the British work. Particle-beam weapons could, theoretically, become reality.

Keegan's evidence suited Teller's purpose. Teller gained control of the second element in his trinity of influential spheres by convincing security forces of their imminent vulnerability to a Soviet attack. Having made Livermore into what he wanted, he now needed the military establishment on his side. The Pentagon was convinced of the need to build a screen to protect its missiles and Air Force Intelligence assembled evidence for Teller to use in securing his third and most important sphere of influence. This was the political commitment to fund a clandestine research effort, first mimicking the work thought to be going on in the USSR to see what the Soviets could achieve and then building up a defence

programme in response. Teller needed the political support which he had failed to obtain during Eisenhower's presidency.

To ensure a steady flow of funds, Teller had to convince the President that a major technology breakthrough by the Soviet Union was not only destabilising but imminently threatening in a military sense.

By the 1960s, breakthroughs in laser engineering had opened prospects for a completely new class of weapons in addition to directed-energy applications of particle beams. Scientists at Livermore were working on nuclear bombs and high-energy weapons research, so the laboratory was well placed to take research on lasers. Even in the 1960s, lasers showed several possibilities as weapons.

There were now three types of antiballistic missile technology: kinetic energy weapons launched by missiles on impact trajectories; nuclear weapons detonated in the path of approaching warheads; and directed energy weapons involving lasers and particle beams. To pave the political way, Teller invited the governor of California to Livermore to see the progress on beam research. The governor of California was Ronald Reagan. Teller forged a friendship with Reagan and through the years continued to keep him informed about work at Livermore.

Recruiting physicists

By this time, Teller was deeply involved with the Hertz Foundation, a private organisation set up by John D. Hertz, also the founder of Rentacar and Yellow Cab. The Hertz Foundation rapidly came to play a key role in organising the campaign to fund beam research. It was the mechanism through which Teller recruited young physicists with the "right" political leanings. The foundation operated in secret, and included on its board of trustees men who were uniquely equipped to wield influence in wide circles: Edgar Hoover, head of the FBI; Robert Lehman, head of a major investment bank; and Floyd Odlum, who privately financed development of the Atlas missile before the government provided the money for its development.

The Hertz Foundation needed a charismatic scientist who could attract young graduates to Livermore. It found such a scientist in Lowell Wood, a physicist who first met Teller in 1960. Wood, born in 1941, excelled in theoretical mathematics. Teller brought him to Livermore in 1966, where he quickly became an interviewer for Hertz. The brochure handed to each interviewee said that applicants had to agree to "morally commit themselves to make their skills and abilities available for the common defence". Applicants were asked if they had read Teller's book *Legacy of Hiroshima*, in which he warned that Russia was "an opponent more powerful... and more dangerous than German Nazism".

Gradually, throughout the 1960s and early 1970s, work proceeded on repeating what the Russians were thought to be up to. Increasingly, the weapons that might come from this research came to look more attractive. The research results provided Teller and Keegan with the means to attract funds from the White House, bypassing the usual funding route of Congressional committees. The work was too secret to discuss in open budget hearings. As part of this effort, Keegan tried to get word through to President Ford that the USSR was building a powerful antimissile beam weapon.

Keegan took his dossier to people in the CIA and revealed spy satellite pictures purportedly showing massive construction at Semipalatinsk and the Sary Shagan ABM site. Keegan's men dubbed the Semipalatinsk area PNUT, for possible nuclear underground test site. The CIA was not convinced and called it URDF-3, for unidentified research and development facility three. In 1975, frustrated by the unbelieving CIA group, Keegan went straight to William Colby, the director of the CIA, who then set up advisory panels. A year later, Keegan briefed the panels on research conducted by the scientists at Livermore. They proved that scientists in



An impression of kinetic energy weapons (below), and the results (left) of laboratory tests on kinetic energy weapons



POP/ARIS

the Soviet Union could assemble an antimissile beam weapon. The only question was, were they?

Keegan and the CIA did not give this information to President Ford. The elections were coming and nothing, they believed, would be gained by breaking the tight secrecy that held it within the CIA and the Keegan/Teller group. But, when Henry Kissinger flew to meet the Russians for arms talks, Colby wrote to him saying there was "a facility [in the Soviet Union] related to nuclear functions that were unknown but that might have high scientific applications".

By the end of 1977, President Carter had stiffened his election attitude about "riddling the world of nuclear weapons" in response to intensified Soviet antisatellite tests. He remained, however, unconvinced that the USSR was building beam weapons. Nevertheless, research at Livermore and other establishments in the US prompted the White House to see what could be done with directed-energy weapons. Within 18 months, a five-year programme was under way to explore weapons applications, and a working group of 36 scientists was set up to study the possibility of building as quickly as possible an antimissile screen using lasers and particle beams. It was within this five-year effort that Teller pushed the application of nuclear-pumped, X-ray laser weapons.

Using the code name Dauphin, Livermore proved that a small nuclear charge detonated within a cavity would produce the power needed to send X-ray laser beams thousands of kilometres through space to a swarm of missiles, burning a hole through each one. It worked on the principle put forward by Teller in the 1940s. By focusing relativistic X-rays and gamma rays produced by a fission bomb, isotopes of hydrogen could be fused, releasing prodigious quantities of energy. It was the basic principle of the H-bomb. Taking this a stage further, a small hydrogen bomb surrounded by lasing rods would, when struck by the X-rays, emit laser energy across great distances. The entire device would be destroyed in the resulting fireball, but not before it had propagated energetic X-rays. The idea was to point each rod at a separate missile and strike them all simultaneously. Dauphin combined the best of Teller's dream weapons: nuclear bombs in an antimissile system.

Livermore had been searching for the X-ray laser since the early 1960s. In 1977, George Chapline, a physicist, had worked out the design. Under the code name Diabolo Hawk, Chapline's idea was put to the test on 13 September 1978 at the underground nuclear test range in Nevada. It flopped, but not because of theory. The technology let the Livermore scientists down. Back at the drawing board, ideas became more sophisticated and the next test was a success. Scientists from Livermore detonated the Dauphin device on 14 November 1980. There to share the glory were Lowell Wood and a team of scientists (the O-group) from Livermore's nuclear weapon design section. The Hertz Foundation kept O-group up to strength by recruiting a stream of bright young graduates.

A prolific array of laser and beam weapons emerged in the late 1970s, under names such as Chair Heritage, White Horse and Sipapu. The political obstacles had been largely cleared when Carter's more hawkish approach to the USSR brought the resignation of Cyrus Vance, the secretary of state. Carter replaced Vance with Zbigniew Brzezinski, the right-wing former national security adviser. Brzezinski listened to Keegan and consulted Teller. Carter was persuaded to fund research on a grander scale.

When Ronald Reagan came to power in January 1981, he immediately sought a meeting with Teller, who recommended George Keyworth as the President's science adviser. Keyworth was from Los Alamos and had sided with Teller over the nuclear-pumped, X-ray laser. Billions of dollars had now been channelled from the Pentagon's coffers into a co-ordinated series of separate projects, each of which was known exclusively to the people working on it.

The Heritage Foundation in Washington DC provided the

venue for scientists and industrialists who were lobbying the White House for a formal, publicly open, antimissile programme. Key officials from the Pentagon joined the group, which put together a plan for national strategic defence, using Livermore's nuclear X-ray laser, kinetic impact weapons and beam devices. Teller was important as the vocal advocate and esteemed patriarch, capable of getting the ear of Keyworth and the President. Reagan would listen to Teller, consult his science adviser and Keyworth would give his blessing.

The group at the Heritage Foundation received top security clearance and first met Ronald Reagan in January 1982. Teller met Reagan several times during the next few months, and had a private session in September to review the entire spectrum of technologies envisaged in the programme. It involved bombs driving X-rays lasers; scores of orbiting kinetic kill vehicles; hundreds of satellites watching every piece of Soviet hardware; ground-based laser beams reflected off mirrors in space onto ascending missiles; and beam weapons in space to attack the rockets that got through. The work was taking up so much money that the programme was jeopardised by keeping it secret.

On 14 January 1983, George Keyworth broke more than 20 years of secrecy when he became the first official even to acknowledge the existence of a programme of research on directed-energy weapons. At the Livermore laboratory he described the nuclear, X-ray laser as playing a vital role in the nation's future defence strategy. All across the US, universities and research facilities were assembling the jigsaw pieces. Any real concern about progress in the USSR with laser or beam research was replaced by a general desire to keep ahead of the Russians.

The defence strategy was developing into a political tool, one which could serve the President well as a public display of international concern and national morality. In March, 1983, Reagan put before the American people his dream of building "the means of rendering the ballistic missile threat impotent and obsolete". It would be called the Strategic Defense Initiative, and purported to protect civilians from the awesome consequences of a nuclear war and to preserve the basic tenet of America's strategic forces. That tenet was vividly expressed during the 1960s when America's silo-based missile force was described in a Pentagon policy document as being in need of protection so as to "retain an ability to savage the aggressor at will".

During 1984, James Fletcher, who had been administrator of NASA, headed a defence technology study which proclaimed "powerful new technologies" for a defence strategy based on a missile programme. In January 1984, the White House set up the SDI Office and appointed General James Abrahamson as its head. Within two years, Fletcher was back as NASA's boss. Wood now has a more visible role at Livermore in the goldfish bowl of public interest about the SDI. Many believe that the SDI could not have arrived without what some dub the unholy trinity: an irreversible commitment from the Pentagon; a team of dedicated, politically orientated, young scientists; and a power group to ensure that having got this far the SDI is never abandoned.

In its first full budget, the SDI programme received \$1400 million for the 1985 financial year. This was less than the amount allocated to laser and beam weapon projects in 1984. There was a price for going public. In succeeding years, the SDI office received only 60 per cent of the funds it asked for. But the programme that began so long ago had survived greater challenges than all its opponents could mobilise. It had been shown to be bigger than the highest office in the land and would not go away. It is most unlikely that it ever will. □

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Mark Morgan/Science Photo Library

Zoologists need not apply

A look through the jobs advertised in *New Scientist* and *Nature* suggests that Britain is training the wrong sort of biologists

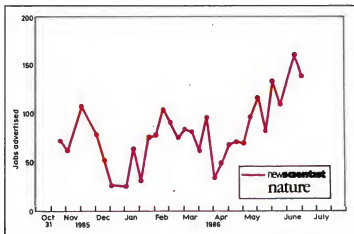
John Pirt

RELIABLE information about the demand for scientific expertise is more important than ever if universities, polytechnics and research councils are to deploy their shrinking resources effectively. With this in mind, I and some of my colleagues at King's College, London, have tried to assess the number of job opportunities in the biological sciences by perusing the job advertisements in *Nature* and *New Scientist*. Our survey suggests that there is a considerable demand for biology graduates. However, we found a wide variation in the demand for graduates in the various subdisciplines of biology, with biochemistry and molecular biology at the top.

We found a conspicuous mismatch between the number of awards the Science and Engineering Research Council makes for the various subdisciplines of biology and the number of jobs available. What is more, there is a great disparity between the SERC's support for training for research in chemistry and that in biological science. This is amply demonstrated by the fact that the ratio of job opportunities to studentships is about 2:1 in chemistry, 6:1 in biochemistry and 10:1 in other biological sciences. This lack of support for research training in biological sciences is ominous for the development of biotechnology in Britain.

It was V. V. Nalikov, in the Soviet Union, who first thought of looking at advertisements in *New Scientist* and *Nature* as

a means of assessing job opportunities in science. In his book *Faces of Science* (ISI Press, Philadelphia, 1981), Nalikov described how he had surveyed the advertisements for jobs in various disciplines, in an attempt to assess technological change. Subsequently, Mike Simpson and Paulette Smith at



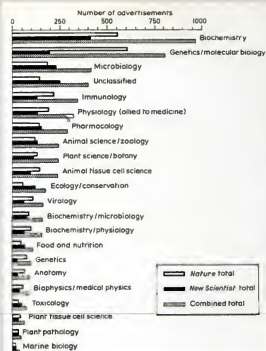
Biological jobs advertised in *New Scientist* and *Nature* week by week

Table 1: Job opportunities in the biological sciences, advertised in *New Scientist* and *Nature* (1985/86)

Subdiscipline	<i>Nature</i> total*	<i>New Scientist</i> total†	Combined total	Per cent of total jobs	Average jobs per week
Biochemistry	556	413	969	17.6	16
Genetics/molecular biology	609	197	806	14.7	13
Microbiology	185	230	415	7.5	7
Unclassified	145	253	398	7.2	7
Immunology	218	130	345	6.3	6
Physiology (allied to medicine)	190	130	320	5.8	5
Pharmacology	142	151	292	5.3	5
Animal science/zoology	118	127	244	4.4	4
Plant science/botany	133	108	241	4.4	4
Animal tissue cell science	144	94	238	4.3	4
Ecology/conservation	55	118	173	3.1	3
Virology	106	55	161	2.9	3
Biochemistry/microbiology	81	79	160	2.9	3
Biochemistry/physiology	93	60	153	2.8	2
Food and nutrition	40	64	104	1.9	2
Genetics	75	22	97	1.8	2
Anatomy	65	25	90	1.6	1
Biophysics/medical physics	51	38	89	1.6	1
Toxicology	25	48	73	1.3	1
Plant tissue cell science	38	22	59	1.1	1
Plant pathology	22	16	37	0.7	1
Marine biology	18	18	35	0.6	1
TOTALS	3108	2394	5496	100.0	90

* 31 weeks in period 31 October 1985–26 June 1986

† 29 weeks in period 31 October 1985–26 June 1986



the University of Sheffield, using a similar technique, scanned *Chemistry in Britain* to try to assess the number of jobs available for chemists (*New Scientist*, 7 August 1986, p 51). We at King's were primarily interested in assessing the demand for biologists, so we confined our survey to advertisements for jobs in biological sciences. Our survey covered 30 weeks between 31 October 1985 and 26 June 1986. *New Scientist* and *Nature* each carried about 80 to 100 advertisements for jobs in biological sciences each week, giving a total of 4000 to 5000 for the year (see graph on p 41).

The great diversity of subjects within biology, as compared with, say, physics and chemistry, meant that we had to be particularly careful in apportioning advertisements to various subdisciplines (see Table 1 and the accompanying diagram). We defined the subdisciplines partly on classical academic divisions, and partly on the way in which disciplines are applied. For the purposes of the study, we ignored those advertisements that called for a qualification in medicine, veterinary science, agriculture, horticulture, nursing or pharmacy. Similarly, although we included advertisements for jobs in higher education, we ignored those for schoolteachers.

Table 2: Jobs advertised for biologists and chemists over the past 25 years

	1960	1969	1986
<i>NATURE</i> *			
Biochemistry	243	439	932
Pharmacology	79	130	238
Other biological sciences	542	1185	4034
<i>NEW SCIENTIST</i> *			
Biochemistry	114	403	741
Pharmacology	50	122	271
Other biological sciences	442	1011	3281
		Nalakov†	Simpson & Smith‡
Chemistry	947	555	677

* 1960 and 1969 from Nalakov survey; 1986 from present survey

† Derived from advertisements in *Nature* and *New Scientist*

‡ Survey of job opportunities for chemists derived from advertisements in *Chemistry in Britain*

We included postgraduate studentships. We allowed for the fact that advertisements in *New Scientist* and *Nature* cover to a large extent the same pool of job opportunities, by considering the total number of opportunities to be half the sum of the vacancies advertised in the two journals.

Some advertisements called for a combination of two or more subdisciplines, so we split the jobs equally among them. When the advertisement did not specify the combination of subdisciplines, we divided the jobs equally among up to three subdisciplines. We called "unclassified" those jobs that did not call for a specialised subdiscipline: most of these jobs were in marketing and information science. Often, the advertisements offered several vacancies but did not specify the number. In such cases, we assumed that there were two vacancies.

Our survey indicates the types of biological scientists that are in most demand. The greatest demand is for biologists specialising in biochemistry and molecular biology (see Table 1). Indeed, jobs in biochemistry, genetics and molecular biology, together with half of those falling into the biochemistry/microbiology group, accounted for 35 per cent of all the biological posts advertised.

Of the three subdisciplines based on the study of organisms—that is, botany, zoology and microbiology—microbiology is the most in demand. Thus, for botany, zoology and microbiology respectively, the ratio of the job opportunities is 1:1:2. This is remarkable when one considers that microbiology was hardly recognised as a separate discipline before 1960. The development of biotechnology has undoubtedly driven the growth of



Out with the old: the classical view of biology has led to the neglect of subjects which hold the key to modern biotechnology

Table 3: SERC research studentships awarded in biology and chemistry (1985/86)

Field/university department	Number of job opportunities†	Number of studentships	Job opportunities per studentship
Biochemistry*	962	78	12.3
Genetics/molecular biology†	780	26	30.0
Microbiology‡	442	10	44.2
Animal science/zooology	208	37	5.6
Plant science/botany	208	28	7.4
Total biological sciences	4680	251	18.6
Chemistry	677	316	2.1

* Includes half of biochemistry/microbiology and half of biochemistry/physiology

† Combination of genetics and genetics/molecular biology

‡ Includes half of biochemistry/microbiology

§ Present survey normalised to 12 months

microbiology. All the biological disciplines contribute to biotechnology, and the range of job opportunities revealed by our survey is a measure of the technological demand for each discipline.

What the survey cannot show, of course, is how many new jobs are represented by the advertisements. The creation of one vacancy could set in motion a chain of replacements which ends only when a fresh entrant into the job market fills the gap. Such a chain could magnify the demands in the field and emphasise where the shortage of scientists is most acute.

On the other hand, the number of advertised jobs will tend to underestimate the number of vacancies. Many posts are filled through unsolicited applications to the employers or by recruiting visits to educational institutes.

I have combined the results of our survey for 1985 to 1986 with those of Nalikov for the 1960s, in an attempt to indicate the growth in the number of job opportunities over the past 25 years (see Table 2). The growth is spectacular. From 1969 to 1986, for example, the compound growth rate in job opportunities in the biological sciences has been nearly 7 per cent a year, which corresponds to a doubling of the demand every 10 years. Nalikov correctly inferred from his survey that the rise in demand for biologists in the 1960s presaged the growth of biotechnology. The development of biotechnology was well under way before the development of the recombinant-DNA technology in the mid-1970s.

I have also included in Table 2 data from the surveys of Simpson and Smith, at Sheffield, who tried to assess the

demand for chemists by looking at advertisements in *Chemistry in Britain*. Their surveys indicate that in Britain the demand for chemists has declined by 30 per cent since 1960. In contrast, as the results of our own survey reveal, the demand for biochemists has increased several fold, and now substantially exceeds the demand for chemists. The decline in the number of job opportunities for chemists could be because they have been replaced by biochemists. Also, up to the 1960s, chemists filled many microbiological jobs (including my own!). Such substitutions are no longer feasible because of the greater specialisation within the biological disciplines.

Simpson and Smith also

looked at advertisements for chemists in *New Scientist*. They found 8429 jobs advertised between March 1985 and February 1986. Comparing this with the data from our own survey indicates that advertisements for biological scientists make up about half of the total.

The British government puts great store these days on making university education relevant to the needs of the community. To see how well the number of training opportunities in biological sciences matches up to the number of jobs available, I have listed the number of research studentships awarded by the Science and Engineering Council in 1985/86 alongside the number of job opportunities, as revealed by our survey (see Table 3). I have also included figures for chemistry, using the data obtained by Simpson and Smith.

As the table shows, there is a gross mismatch between the number of research training awards and the demand for people in various subdisciplines of biology, with, for example, 44.2 job opportunities per studentship in microbiology, and only 5.6 opportunities per studentship in zoology. The figures in the table confirm my own impression that the SERC makes awards on a historical basis, favouring classical zoology and botany, without referring to the demand for biotechnologists.

Even more disturbing, perhaps, is the disparity in the ratio of studentships to job opportunities between biological subjects and chemistry. The number of chemistry studentships per job opportunity greatly exceeds the number for the biological sciences. This seems at variance with the SERC's declared policy of giving selective support to "relevant science". The fact that the other research councils make available a few more studentships in the sciences does not materially alter this position.

Supply must meet the demand

British universities and polytechnics awarded 5122 first degrees in the biological sciences in 1985/86. Comparing that figure to the results of our survey, the ratio of job opportunities to the number of graduates is 0.91. In contrast, for chemistry, the number of graduates for 1983/84 was 2415, so the ratio of job opportunities to the number of graduates is only about 0.28.

Superficially, it would appear from this that the job prospects for biology graduates are far better than those for chemistry graduates. However, during 1985/86, only about 40 per cent of biology graduates found permanent jobs. A further 5 per cent found temporary employment. These figures come from the *University Statistical Record*. Unfortunately, this publication does not classify biological scientists according to their subdisciplines, so it is impossible to see how the graduates in the various subdisciplines fared. Nevertheless, there are hints that the types of biologists that we produce in Britain do not square up to the demand. For instance, we seem to be producing a large excess of zoologists. It is well known that classical zoology has dominated biology curricula in schools. In my view, the historical dominance of classical zoology and botany has resulted in the neglect of biochemistry, molecular biology and microbiology—the keys to modern biotechnology. If we are to get round this problem, we must retrain our school-leavers.

The way in which the SERC distributes its resources between the physical and biological sciences suggests that it still regards biological science as an academic luxury. The results of our survey suggest otherwise. In reality, the new molecularly-based biology is opening up a new world of opportunities that will fundamentally affect every aspect of life. We need a new distribution of resources to cope with this revolution in ideas. □

Professor John Pirt is head of the department of microbiology at King's College, London.

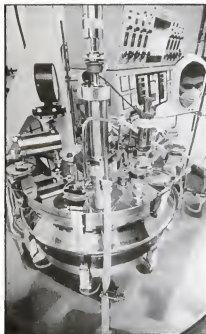
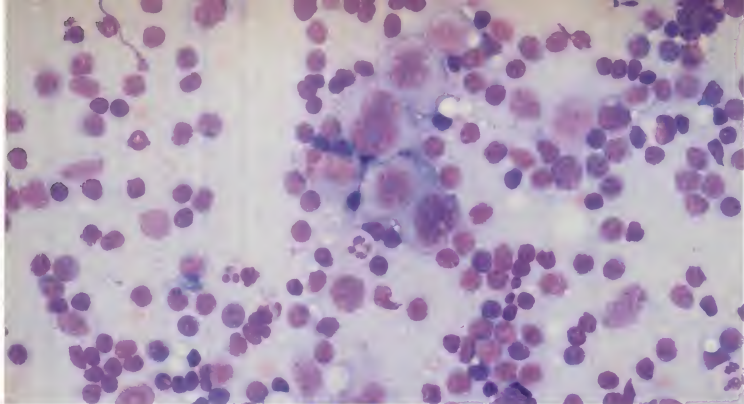


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The direction of time

The laws of physics do not distinguish between the past and the future. But thermodynamics, cosmology and common sense tell us that the arrow of time points only in one direction

Stephen Hawking

THE PAST is a foreign country: they do things differently there." So wrote L. P. Hartley in *The Go-between*. But why is the past so different from the future? Why do we remember events in the past, but only dimly foresee what is going to happen? Is there any connection between the direction in which we perceive time to pass and the expansion of the Universe? If so, will the direction of time reverse if and when the Universe stops expanding and starts to contract again?

Scientists believe that the laws of physics govern everything that happens. These laws do not distinguish one direction of time from the other, any more than they prefer a direction in space over the opposite direction. More precisely, the laws do not change under the combination of the three operations known as *C*, *P* and *T*. The operation *C* means change particles for antiparticles. *P* means change to the mirror image, so left and right are interchanged. And *T* means reverse the direction of motion of all particles: in effect, running the motion backwards.

The combination of operations, *C* and *P*, does not change the laws of physics. Life would be just the same for the inhabitants of another planet who were our mirror images and who were made of antimatter. The laws of physics are also unchanged by the combination *C*, *P* and *T*. They must therefore also be unchanged under the operation *T* alone. Yet there is a big difference between the forward and backward directions of time in ordinary life. Imagine a cup of water falling off a table and breaking in pieces on the floor. If you take a film of this, you can easily tell whether it is being run forwards or backwards. If it is backwards you will see the pieces suddenly gather themselves together off the floor and jump back to form a whole cup on the table. You can tell that the film is being run backwards because you never observe this kind of behaviour in ordinary life.

We do not see broken cups gathering themselves together off the floor and jumping back onto the table because the second law of thermodynamics forbids it. The second law says that disorder, or entropy, always increases with time. In other words, it is Sod's law: things get worse. An intact cup on the table is a state of high order but a broken cup on the floor is a disordered state. The cup on the table in the past can become the broken cup on the floor in the future, but not the other way round.

The increase of disorder or entropy with time is one example of what is called an arrow of time—something that gives a direction to time, distinguishing the past from

the future. There are at least three different arrows of time. First, there is the thermodynamic arrow of time, the direction of time in which disorder, or entropy, increases. Secondly, there is the psychological arrow of time. This is the direction in which we feel time passing—the direction of time in which we remember the past but not the future. Finally, there is the cosmological arrow of time. This is the direction of time in which the Universe is expanding rather than contracting.

I shall argue that the thermodynamic arrow determines the psychological arrow and that these two arrows always point in the same direction. If we make a natural assumption about the state of the Universe, the two arrows are also related to the cosmological arrow of time, though they may not point in the same direction. However, I shall argue that it is only when they do point in the same direction as the cosmological arrow that conditions are suitable for the development of intelligent beings who can ask the question: Why does disorder increase in the same direction of time as that in which the Universe expands?

The second law of thermodynamics is based on the fact that there are many more disordered states than there are ordered ones. For example, consider the pieces of a jigsaw in a box. There is one, and only one, arrangement in which the pieces make a complete picture. On the other hand, there are a very large number of arrangements in which the pieces are disordered and do not make a picture.

Suppose a system starts out in one of the small number of ordered states. As time goes by, the system will evolve according to the laws of physics and its state will change. At a later time, there is a high probability that it will be

in a more disordered state, simply because there are so many more disordered states. Thus disorder will tend to increase with time if the system obeys an initial condition of high order.

Suppose the pieces of the jigsaw start off in the ordered arrangement in which they form a picture. If you shake the box, the pieces will take up another arrangement. This will probably be a disordered arrangement in which the pieces do not form a proper picture, simply because there are so many more disordered arrangements. Some groups of pieces may still form parts of the picture, but the more you shake the box, the more likely it is that these groups will get broken up and the pieces will be in a completely jumbled state in which they do not form any sort of picture. Thus, the disorder of the pieces will probably increase with time if they obey the initial condition



Michael Finn



that they start in a state of high order as a picture.

Suppose, however, that God decided that the Universe should eventually finish up in a state of high order, but that it did not matter what state it started in. Then, at early times the Universe would probably be in a disordered state, and disorder would decrease with time. You would have broken cups gathering themselves together and jumping back on the table. However, any human beings who were observing the cups would be living in a universe in which disorder decreased with time. Such beings would have a psychological arrow of time that was backwards. That is, they would remember events at late times, and not remember events at early times.

It is rather difficult to talk about human memory because we do not know how the brain works in detail. We do, however, know how computer memories work. It is reasonable to assume that the arrow for computers is the same as that for humans. If it were not, one could make a killing on the stock exchange by having a computer that would remember tomorrow's prices.

A computer memory is a device that can be in one of two alternative states. An example would be a superconducting loop or wire. If there is an electric current flowing in the loop, it will continue to flow because there is no resistance. On the other hand, if there is no current, the loop will continue without a current.

One can label the two states of the memory, 1 and 0. Before an item is recorded in the memory, the memory is in a disordered state, with equal probabilities for 1 and 0. After the memory interacts with the system to be remembered, it will definitely be in one state or the other, according to the state of the system. Thus the memory passes from a disordered state to an ordered one. However, in order to ensure that the memory is in the right state, it is necessary to use a certain amount of energy. This energy is dissipated as heat and increases the amount of disorder in the Universe. One can show that this increase of disorder is greater than the increase in the order of the memory. Thus, when a computer records an item in memory, the total amount of disorder in the Universe increases. The direction of time in which a computer remembers the past is the same as that in which disorder increases.

Our subjective sense of the direction of time, the psychological arrow of time, is determined by the thermodynamic arrow of time. This makes the second law of thermodynamics almost trivial. Disorder increases with time because we measure time in the direction in which disorder increases.

Why should the Universe be in a state of high order at one end of time, the end that we call the past? Why is it not in a

state of complete disorder at all times? After all, this might seem more probable. And why is the direction of time in which disorder increases the same as that in which the Universe expands? One possible view is that God simply chose that the Universe should be in a smooth and ordered state at the beginning of the expansion phase. We should not try to understand why, or question His reasons because the beginning of the Universe was the work of God. But the whole history of the Universe could be said to be the work of God. It appears that the Universe evolves according to well-defined laws. These laws may, or may not, be ordained by God, but it seems that we can discover and understand them. Is it therefore unreasonable to hope that the same or similar laws may also hold at the beginning of the Universe?

The beginning of the Universe

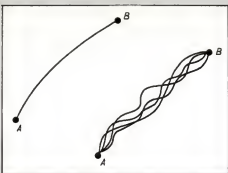
The best theory we have to describe the structure of space and time is general relativity, formulated by Albert Einstein in 1915. In this theory, the three dimensions of space and the one dimension of time are combined together to form a four-dimensional space. This four-dimensional space is not flat, as one might expect, but it is curved or warped by the matter and energy in the Universe. According to general relativity, the Universe would start with what is called a singularity—a state of infinite density in which space and time would be curved up with an infinitely small radius. Under such conditions, all the known laws of physics would break down. Thus, one could not use them to predict how the Universe would begin. The Universe could have started out in a very smooth and ordered state. This would have led to well-defined thermodynamic and cosmological arrows of time, like we observe. But it could equally well have started out in a very lumpy and disordered state. In this case, the Universe would already be in a state of complete disorder, so disorder could not increase with time. It would either stay constant, in which case there would be no well-defined thermodynamic arrow of time. Or it would decrease, in which case the thermodynamic arrow of time would point in the opposite direction to the cosmological arrow. Neither of these possibilities would agree with what we observe.

General relativity is what is called a classical theory. It does not take into account the fact that the uncertainty principle of quantum mechanics governs what happens on a very small scale. This uncertainty does not matter when the Universe is large and the curvature of space-time is small. But classical general relativity brings about its own downfall by predicting that the Universe began with a singularity. When the curvature of space-time becomes large, quantum effects will become important and the classical theory will cease to be a

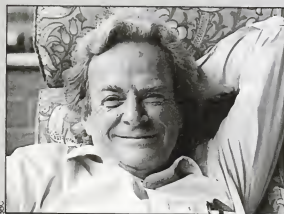
Summing over histories: an alternative quantum view

THE FUNDAMENTAL difference between quantum mechanics and classical, Newtonian, mechanics is brought out when we look closely at the way a particle, such as an electron, actually does get from one point *A* to another *B*. In the classical view, a particle at point *A* has a definite speed in a definite direction. Because it is acted upon by external forces, it moves along a precisely determinable path, which passes through, or ends at, point *B*. The quantum-mechanical view is different. We cannot know, not even in principle, both the position and momentum of a particle simultaneously. There is an inherent uncertainty about where the particle is going, in line with the principle formulated by Werner Heisenberg. If a particle starts out at point *A* and is later detected at point *B* we cannot know how it got from *A* to *B*, unless we watch it all the way along its path.

Richard Feynman, from the California Institute of Technology, applied this quantum-mechanical view to the history of particles as presented in the kind of space-time diagrams used by scientists studying relativity. These are diagrams like graphs, with one axis representing time and the other space. Curves on the diagram, world lines, represent particle trajectories, or histories, some of which are ruled out because they would involve travel faster than light, but many of which indicate valid ways for a particle to get from *A* to *B*. Some of these trajectories, or paths, are very straightforward and direct; others meander about. Feynman's maps include time as well as space, and on them some of the trajectories represent fast passages of a particle, and others represent slow passages. But each path, direct or circuitous, fast or slow, has associated with it a definite probability that can be calculated.



Classical physics says that a particle follows a unique trajectory from A to B. According to Richard Feynman, we must add up the effect of all possible paths from A to B



The probabilities of the world lines are not all "in step" with one another, and like the amplitudes of ripples on a pond they can interfere with one another to reinforce

the strength of one path while cancelling out others. Feynman showed that when all the amplitudes corresponding to possible particle trajectories are added together, the result of the interference is to wipe out all the possible contributions except the ones very close to the trajectory corresponding to the path from *A* to *B* in accordance with classical mechanics.

The technique has been used in fully worked-out detail only for some very simple, special cases. The number of paths involved is so enormous in most cases that it is quite impractical to apply Feynman's technique in its pure form. But the concept underlying this approach, and the fact that it can be shown mathematically to make the same predictions as Erwin Schrödinger's version of quantum physics, are fundamentally important. There are also ways to generalise the technique, and to calculate its broad implications without calculating every path in detail. Feynman has proved, for example, that as well as the most probable path corresponding to the classical trajectory, only paths close to this trajectory need be included in the calculations. The probabilities from the other paths always cancel each other out.

The conventional quantum view has it that there is *no* trajectory: from Feynman's point of view, we have to take account of *every* trajectory. This approach to describing the trajectories of particles is called the "path integral" technique, because it involves adding up different possible paths, or sometimes, more grandiosely, the "sum over histories" approach.

John Gribbin

a good description of the Universe. One has to use a quantum theory of gravity, not classical general relativity, to understand how the Universe began.

We do not yet know the exact form of the correct quantum theory of gravity. It may be some version of supergravity or it may be the novel theory of superstrings. Or it may be some theory that we have not yet thought of. However, we expect certain features to be present in any viable theory. One of these is Einstein's idea that the gravitational field, and maybe other fields, can be represented by a curved space-time. Space-time is warped or distorted by the mass and energy in it. Objects try to follow the nearest thing to a straight path through space-time. But, because space-time is curved, their paths appear to be bent by a gravitational field.

Another idea that we think will be part of any ultimate theory is Richard Feynman's proposal that quantum theory can be formulated as a "sum over histories" (see Box). In its simplest form, the idea is that a particle has every possible path or "history" in space-time. Each history has a certain "probability" that can be calculated. For this idea to work, one has to pretend that space-time is "Euclidean". In other words, time is just like another direction in space. One adds up the probabilities for all the particle histories with certain properties, such as passing through certain points at certain times. One then has to extrapolate the result back to real space-time in which time is different from directions in space. This is not the most familiar approach to quantum theory, but it gives the same results as other methods.

In the case of quantum gravity, Richard Feynman's idea of a "sum over histories" would involve summing over different possible histories for the Universe, that is, different curved space-times. One has to decide how the space-times that one includes in the sum behave at early and late times. This will determine how the Universe starts and finishes. Whether it starts or finishes in a state of order or disorder. This in turn will determine whether there is a well-defined thermodynamic arrow of time and whether it agrees with the cosmological arrow.

In classical general relativity there are only three possible behaviours of the Universe in time: first, it may exist for an infinite time in the past and the future; secondly, it may have a beginning or an end at a finite time; or thirdly, it may be periodic in time.

In fact, work that Roger Penrose at University of Oxford and I did about 20 years ago showed that if one made certain reasonable assumptions, it had to be the second possibility. The Universe would have begun at a singularity of infinite curvature about 15 000 million years ago. As I explained, one could not predict how the Universe would start or what the thermodynamic arrow of time would do because the laws of physics would break down at the singularity.

However, in a quantum theory of gravity, there is another possible way for the Universe to behave in time. In Feynman's "sum over histories", one uses curved space-times that are "Euclidean". That is, they have time on the same footing as directions in space. In this case, it is possible for the

curved space-time to be finite in extent but without any boundaries or edges in time or space. It would be like the surface of the Earth, but with two more dimensions. The surface of the Earth is finite in extent but does not have any boundaries or edges. If you sail off into the sunset, you do not fall over the edge or run up against a barrier. Last year, I tested this by experiment. I went round the world and arrived back where I started. I did not fall off the edge and I did not run up against a brick wall.

In 1983, Jim Hartle at the University of California at Santa Barbara and I suggested that the "sum over histories" should be taken over all Euclidean curved space-times that are finite in extent but have no boundary or edge. This proposal can be paraphrased as: "The boundary condition of the Universe is that it has no boundary." It would mean that the Universe would be completely self-contained. It would not need any external agency to set it going or to choose how it began. The laws of physics would hold at every point. They would determine completely how the Universe behaved.

The globe of space-time

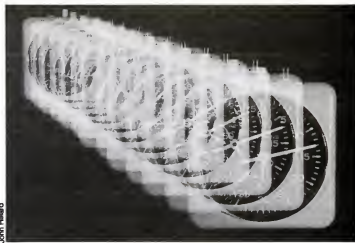
Space-time could be like the surface of the Earth with degrees of latitude being like time. The circles of latitude start at a single point at the North Pole. As one goes south, the circles of latitude get bigger. This is like the Universe starting at a single point and expanding. The Universe would reach a maximum size at the equator and would contract again to the South Pole. Even though the North and South Poles are the beginning and end of degrees of latitude, they are perfectly ordinary points on the Earth's surface. There is no edge or singularity at the North Pole (*New Scientist*, 16 August 1984, p 10). Similarly, the beginning and end of time would be ordinary points of space-time at which the laws of physics held.

If the "no boundary" proposal is correct, the laws of physics should determine how the Universe began. Of course, it would be very difficult to work this out exactly, especially as we are not sure of the precise laws that govern quantum gravity. However, Jonathan Halliwell at Cambridge and I have made an approximate calculation which indicates that the Universe would have begun its expansion in a very smooth and ordered state.

It could not have been completely uniform in space because that would violate the uncertainty principle of quantum theory. Uncertainty implies that there had to be small fluctuations in density and velocity. However, the "no boundary" condition implied that these fluctuations were as small as they could be, consistent with the uncertainty principle. The Universe would have started off with a period of exponential or "inflationary" expansion in which it would have increased its size by a very large factor. During this expansion, the fluctuations in density would have stayed small at first, but they would later have started to grow. Regions in which the density was slightly higher than average would have had their expansion slowed down by the gravitational attraction of the extra mass. Eventually, the region would stop expanding and collapse to form galaxies, stars and beings like us. The Universe would start in a smooth and ordered state and would become lumpy and disordered. This would explain the existence of the thermodynamic arrow of time.

But what would happen if and when the Universe stopped expanding and began to contract? Would the thermodynamic arrow reverse and disorder begin to decrease with time? This would lead to all sorts of science fiction-like possibilities for people who survived from the expanding to the contracting phase. Would they see broken cups gathering themselves together off the floor and jumping back on the table? Would they be able to remember tomorrow's prices and make a fortune on the stock market?

At first, I believed that disorder would decrease when the Universe recollapsed. This was because I thought that the contracting phase would be the time-reverse of the expanding phase. However, a colleague of mine, Don Page of Pennsylv-



vania State University, has pointed out that this was not required by the "no boundary" condition. Further, a student of mine, Raymond Laflamme, found a model of the Universe in which the contracting phase was very different from the expanding phase. I then realised that, although it was possible for the Universe to contract back to a smooth and ordered state, it was much more likely to contract to a very disordered state, because there are so many more disordered states. Thus, the thermodynamic arrow of time will not reverse. It will continue to point in the same direction.

There remains the question: Why do the thermodynamic and cosmological arrows point in the same direction? Why does disorder increase in the same direction as that in which the Universe expands? If one believes that the Universe will expand and then contract again, as the "no boundary" proposal implies, this becomes a question of why we should be in the expanding phase, rather than the contracting phase.

One answer is that conditions in the contracting phase would not be suitable for the existence of intelligent beings who could ask the question: Why is disorder increasing in the same direction of time as that in which the Universe is expanding? The inflation in the early stages of the Universe implies that the Universe will not recollapse for a very long time. By then all the stars will have burnt out and the protons, neutrons and other heavy particles in them will probably have decayed into light particles and radiation. The Universe would be in a state of almost complete disorder or thermal equilibrium. There would be no thermodynamic arrow of time. Disorder could not increase because the Universe was in a state of complete disorder already. However, a well-defined thermodynamic arrow is necessary for intelligent life to operate. Human beings have to consume food, which is an ordered form of energy, and convert it into heat, which is a disordered form of energy. Thus, intelligent life could not exist in the contracting phase of the Universe. This is the explanation of why we observe the thermodynamic and cosmological arrows of time to point in the same direction. □

Something to remember

IF you have remembered every word in this article, your memory will have recorded about 150 000 bits of information. Thus, the order in your brain will have increased by about 150 000 units. However, while you have been reading the article, you will have converted about 300 000 joules of ordered energy, in the form of food, into disordered energy, in the form of heat which you lose to the air around you by convection and sweat. This will increase the disorder of the Universe by about 3×10^{12} units, about 20 million million million times the increase in order because you remember my article. □

Stephen Hawking is Lucasian Professor of Mathematics at the University of Cambridge.

All things bright and poisonous

Insects that deter predators by tasting nasty are often brightly coloured. But how can it be in the interests of the prey to advertise itself to its enemies?

Tim Roper

IN THE unceasing evolutionary battle between predators and prey, some species have evolved ways of ensuring that they are a distasteful meal for the predator. Many insects make themselves nasty or dangerous to eat by storing foul-tasting or poisonous chemicals within their bodies. Others release similar substances from specialised glands when they are attacked. Sometimes the insect synthesises these chemical deterrents. More often, the insect obtains them from the plant it eats (the plant having evolved the toxin in the first place as a defence against its predators). Other insects, such as bees, wasps and hornets, make themselves objectionable to predators by means of painful stings. Chemical defences are not confined to insects: tropical frogs and toads have evolved some of the most potent biological toxins known to exist—agents that, at incredibly low doses, arrest a predator's heartbeat, paralyse it or bring vital parts of its nervous system to a standstill within seconds.

Some distasteful or dangerous prey are, like the vast majority of undefended animals, hard to see. For example, the buff-tip moth, which tastes nasty, is also cryptic: it is camouflaged to imitate a birch twig. Such a combination of camouflage and chemical defence makes perfect biological sense. It is entirely reasonable, from biological theory, that an animal should try to avoid capture by hiding from its predators, while at the same time having some means of defending itself should it be detected.

What is more puzzling is that, far from being hard to detect, most noxious prey seem to go out of their way to make themselves as conspicuous as possible by sporting contrasting stripes and spots of red, yellow, white, black and purple, by being glossy and iridescent, and by behaving in a generally flamboyant manner. This is the phenomenon of warning or "aposematic" coloration. It has presented a long-standing evolutionary paradox, not least to Charles Darwin himself. In



It looks like a broken twig, but the buff-tip moth is very much alive. Most animals, sensibly, try to hide from predators...

The Descent of Man, Darwin noted that it cannot be in the interests of any individual animal, no matter how well protected by chemical or other deterrents, to advertise itself to would-be predators. If a mutation for bright coloration arose in a population of dull-looking, nasty-tasting insects, inexperienced predators would see the mutants more easily and so would eat them more often. Hence the mutation could never become established. Warning coloration seems doomed to failure as a defensive strategy. Yet it is a real and common biological phenomenon.



... yet the South American poison frog is conspicuously coloured. Why advertise to enemies, even if you are dangerous?



A palm beetle lives flamboyantly in the rainforests of Costa Rica



A scarlet tiger moth in Britain is also bright. Does its colour make it easier to remember its nasty taste?

Warning coloration has evolved in many diverse species, so there must be some compensating advantage that offsets its inherent disadvantage. But what is the advantage? Possible answers have been cropping up ever since the time of Darwin, and recent research has gone some way towards identifying those that are correct. It now appears that warning coloration can help an animal to survive in a variety of ways, depending on how well the predator can learn.

The Victorian naturalist Alfred Russel Wallace suggested the first and most durable solution to Darwin's problem, in correspondence with Darwin himself. Wallace surmised that perhaps a predator could learn to avoid a noxious prey species more easily if the noxious quality were linked to bright colours. This idea seems intuitively reasonable. If you touch a flashing bright red light and receive an electric shock, you will probably remember the experience better than if you received the same shock after touching a dull grey disc. Probably the very reasonableness of Wallace's hypothesis accounts for the fact that few people have felt any urge to test it empirically.

Wallace's idea does not distinguish between two different ways in which bright coloration might enhance a predator's ability to learn to avoid a species of prey. One possibility is that bright coloration is inherently more effective as a danger signal. Some basic property of the predator's nervous system might make it easier for a predator to learn that a bright, rather than dull, colour is associated with, say, a nasty taste. This seems to be the sort of explanation that Wallace had in mind. But there is an alternative hypothesis. An inexperienced predator might attack the colourful prey more frequently than dully coloured prey, and so learn to avoid the conspicuous prey more quickly. Imagine a predator in a natural environment searching for distasteful prey, some of which are cryptic and some conspicuous. The conspicuous prey are

easier to see, so the predator will find and attack them more frequently. Hence the predator will experience a rapid succession of unpleasant associations between conspicuous coloration and bad taste. It will encounter cryptic prey less often, allowing it to forget what it has learnt between one unpleasant experience and the next. According to this argument, predators learn to avoid conspicuous prey more rapidly, not because each individual learning experience is more effective, but because separate experiences occur closer together in time.

Is there any evidence to support either hypothesis? Paul Harvey and his colleagues at the University of Sussex allowed chicks to peck at nasty-tasting crumbs of food scattered around the floor of an enclosure. The researchers dyed half the crumbs to match the floor, making them inconspicuous. The other half contrasted with the floor and were thus conspicuous. At the start of a trial, the chicks ate more of the conspicuous crumbs. They rapidly learnt not to peck at them. By contrast, the chicks rarely pecked at the inconspicuous crumbs to begin with. But even after prolonged experience, chicks never learnt to avoid inconspicuous crumbs completely. These results support the idea that, for prey that

Chicks confronted with dull or striped mealworms show a strong preference for the unpainted worms and reluctance to eat the painted ones



are equally unpalatable, chicks learn to avoid noxious prey more rapidly and more completely the more frequently they encounter the prey when they begin to feed.

Unfortunately, this experiment does not rule out the alternative hypothesis, namely that conspicuous coloration, in itself, causes more rapid "avoidance learning". To prove this, researchers must arrange matters so that an inexperienced predator initially attacks conspicuous and cryptic prey at the same rate. My colleagues and I have recently done this, again using chicks as predators. In one experiment, we repeated Harvey's procedure, but we put in fewer conspicuous crumbs so that inexperienced chicks ate the two types of prey with equal frequency. In another experiment, we allowed chicks to take just a single peck at a nasty-tasting conspicuous or cryptic bead, and then tested their memory some time later. We found that chicks learnt to avoid nasty-tasting crumbs or beads more effectively when they were conspicuous. We also showed that chicks remembered a nasty-tasting conspicuous bead for longer than they did an equally unpalatable but cryptic object. It seems, then, that Wallace was right. Coloration on its own, divorced from any influence it might have on how frequently naive birds capture prey to begin with, can affect how quickly the birds learn to avoid unpalatable prey and how long they remember.

Warning coloration might also have other advantages. John Turner of the University of Leeds has argued that conspicuous coloration works not because it makes the prey conspicuous, but because it makes it different. Turner reasons that conspicuous prey are relatively novel to the predator, because most prey are cryptic. This novelty, he suggests, makes it easier for the predator to associate the appearance of the prey with its noxious qualities. Much work on avoidance learning in both rats and people confirms that it is indeed easier to learn to avoid a harmful stimulus that is novel, than one that is equally harmful but familiar. Thus experimental evidence suggests that being brightly coloured enhances avoidance learning for at least two reasons: it is inherently easier to learn about a conspicuous stimulus, and conspicuousness makes the prey look relatively novel.

Yet this is not the end of the matter. It now turns out that some birds do not have to learn to avoid brightly coloured noxious insects: they avoid them innately. Werner Schuler and Elke Hesse of Göttingen University gave inexperienced starlings and domestic chicks a choice between mealworms painted a dull green colour and worms painted in the familiar yellow and black pattern, sported as a warning pattern by wasps and hornets. The birds ate green worms unhesitatingly, but were suspicious of yellow- and black-striped worms. The birds eyed the striped worms and pecked at them, but rarely



Striping in itself does not make prey more aversive to predators. The amount of colour, not its pattern, is what counts

caterpillar, which is highly visible from close to, but surprisingly cryptic if seen from a distance on the bright yellow flowers of its normal food plant, ragwort.

The evolution of innate avoidance in predators sets the stage for further developments in the battle for survival between predator and prey. Brightly coloured insects could "cheat" by ceasing to manufacture toxins, or harmless insects could protect themselves by adopting bright coloration. If either of these strategies became widespread, it would pay predators to go back to learning as a means of distinguishing the innocuous from the genuinely harmful. Some predators have also developed ways to avoid the toxins in some animals by altering their physiology or their behaviour. For example, bee-eaters, a species of bird, are adept at removing the stings from bees before eating them. Warning coloration then becomes positively disadvantageous because it makes the prey conspicuous to predators against which it has no effective defence.

Naturalists have been passionately interested in the coloration of animals for centuries. New models of evolution, which emphasise survival of the individual rather than of the species, have raised new questions about why animals are the colours they are. I suspect, however, that the real reason why so many biologists find the colours of animals fascinating is that so many animals are beautiful. The study of coloration in animals provides a satisfying meeting place for science and aesthetics. □

Dr T. J. Roper lectures in biological sciences at the University of Sussex.

REVIEW

An enormous hat full of treasures

The Natural History of the USSR
by Algirdas Knystautus, *Century*, pp 224, £14.95

Gerald Durrell

THE Soviet Union sits like a sort of enormous hat on the head of the world—an enormous hat full of treasures. Not long ago, my wife and I went into this "hat" to make a series of television films on wildlife and conservation. We were amazed and enchanted by the people and the flora and fauna we encountered.

We visited places as far apart as the Ukraine in the west and Lake Baikal in the east, the Taymyr Peninsular in the north and the Karakum Desert and the Tien Shan Mountains in the south. In all, we covered thousands of miles and travelled by practically every form of transport known to man, from jeeps, planes and helicopters to river steamers, canoes, camels, sledges and skidoos. In the process, we met a host of animals, ranging from bison to musk ox, desert cobras to reindeer, Siberian cranes, sables, Baikal seals, Russian desman, as well as many other creatures. It was an unforgettable experience.

Naturally, when you undertake a trip of this magnitude and complexity, you do your "homework" and read up on the country you are going to. The alarm and despondency were great when we found so little about the natural history of the Soviet Union had been published in English. The little that has been translated is hidden away, buried in various scientific periodicals, and has to be delved for. Eventually, after much research, we came up with a fair amount of information but not nearly as much or as detailed as we would have liked. Imagine our chagrin, then, to return from this trip to find that there had been published this elegant, erudite and beautiful book which would have answered all our questions.

The Natural History of the USSR is not only a lovely production, most beautifully illustrated and extremely well and clearly written, but it also tells you at a glance, with a plethora of maps, where all the major reserves lie and what you are liable to see in them. The hard work of conservation in such a huge and varied terrain is evident. The author, Algirdas Knystautus gives details of the geology, climate, botany and zoology of this enormous tract of land—one-sixth of the Earth's land surface—and he clears up some of the apparent anomalies



we encountered; the difference between specially protected lands, reserves, national parks and sanctuaries, for example, for the Soviets have a complicated conservation system which, nevertheless, seems to

work admirably.

Two of the things mentioned in detail in this book impressed us greatly when we were in the Soviet Union. These are the "Red Data Books" (by now there should be one for each of



From Estonia's wetlands (below) to Siberia's snows, the country boasts the Siberian tiger, largest of all the cats, and the blue-cheeked Bee-eater

the republics) and, under the expert guidance of Vladimir Flint, the captive breeding programmes that have been instituted for such diverse species as the Siberian crane, the goitered gazelle and the lammergeier. We visited most of the captive breeding centres and were very impressed with the work they were doing and the dedication of the staff. Captive breeding to aid species' survival is a comparatively new idea and it is interesting that the Soviets, recognising its importance, are forging ahead with it.

Whether you are a geologist, geographer, botanist, zoologist, or just a potential tourist, you must have this book. It is likely to be the definitive work for many years to come. Now that Mikhail Gorbachov has invented "glasnost" (which one can only hope will last), there may be more opportunities for people from the West to visit this extraordinary and beautiful country.

I can only end by quoting from the foreword by my friend, Vladimir Flint, which sums up, I think, the importance of this book:

"I should like the readers, by learning about the natural history of our country and looking at the beautiful photographs taken by my young friends, besides acquiring knowledge to experience something of the real spirit of this place which they will reach mentally with the help of this splendid book. A knowledge of nature, delight in its perfection and its miracles—this can excite everyone regardless of their country. Out of this is born the spiritual bond between people and nations." □



Can do, will do

James Lick's Monument

by Helen Wright, Cambridge UP, pp 231, £25

Roy Herbert

THE monument is the Lick Observatory on top of Mount Hamilton in California and it is literally a monument. James Lick is buried under the 36-inch refracting telescope, the largest in the world when the observatory was completed in 1886. But the observatory is equally, and possibly more, a monument to its builders, Captain Richard Floyd and Thomas Frasier. All three were extraordinary men. Helen Wright found out how extraordinary they were when she visited the observatory on quite another quest, to discover early records and correspondence that had been left untouched for the best part of a century.

Even the most pedestrian recital of facts about California in pioneering days would reveal how the western seaboard teemed with energy and opportunity, so Wright cannot fail to be interesting about that turbulent time. War with Mexico had added the territory to the US, and gold fever was high. Lick, who arrived in San

Francisco in 1848, was no potential "49-er". He bought land instead of prospecting and became a millionaire.

Apparently, nobody knows when the idea of building the world's biggest telescope occurred to Lick as an old man, but he had had others more eccentric, such as building a pyramid bigger than that at Cheops. He was tactfully dissuaded by friends. A trust, the first of a succession of them, and all bedevilled by Lick's capricious behaviour and the manoeuvrings of lawyers, was set up to get the project going.

Enter Frasier and Floyd. Frasier was a Nova Scotian, a tireless and obsessive worker who had become Lick's ranch foreman. Captain Floyd had been a commerce raider in the Confederate navy during the Civil War. Lick and he hit it off from the start, and with the abruptness that characterised the millionaire and sometimes outraged his contemporaries, he offered Floyd the job of building the telescope.



James Lick's 36-inch refracting telescope was the world's largest in 1886. It is a monument also to Richard Floyd (far left) and Thomas Frasier (standing third from left)

In 1875, Frasier found a site, the top of Mount Hamilton, in wild country and over 4000 feet high. The observatory, still a dream, was offered to the University of California on completion. The reply, though prolix ("In response to this act of spontaneous and almost unparalleled munificence whereby the interests of science,

through one of its most exalted departments . . ." and so on), was one of grateful acceptance. Lick was overjoyed.

Floyd and Frasier, undaunted by what they were setting out to do, built a scientific instrument of unheard-of dimensions and accuracy on the top of a mountain in the wilderness. It was a notable example of the still

NEW YEAR revellers in London's Trafalgar Square will discover, if they read this book, that they are not the first to wallow there. In the rather warmer climes of the last interglacial, hippos lived along the banks of the River Thames, although rather more soberly, I suspect, than their successors. Simon Davis provides a wealth of esoteric information about animals in the past—elephants less than a metre high in Malta, green turtles in the London Docks, and reindeer in the south of France.

Archaeozoology—the study of bones recovered from archaeological sites—is a very earthy subject. All that dirt, crumbling bone, desiccated ligaments and rotting skin seems to colour the books people write. They are often catalogues of species, lists of anatomical minutiae for sorting out the sheep from the goats, and paranoid reflections on the inadequacy of the archaeological record. This book is a welcome departure from this tradition, for it is very firmly about the analysis of bones, not their preservation, recovery and identification.

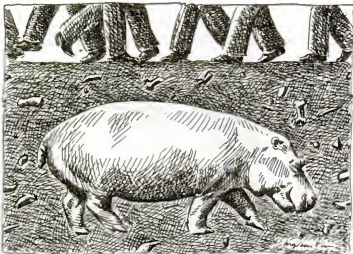
The examples in the first paragraph are not mere empirical titbits, but illustrate the information potential of archaeozoology. The dwarf elephants of

Earthy subject

The Archaeology of Animals

by Simon Davis, Batsford, pp 224, £25.95 hbk, £14.95 pbk

Robert Foley



the Mediterranean are examples of "islandisation", the way in which populations of mammals isolated on islands as part of an impoverished fauna often undergo miniaturisation.

In other words, the distribution and morphology of animals in the past can tell us about biological processes. Equally, they can tell us about changes in

the Earth's climate—the impact of the ice ages was reflected in the extension of reindeer far to the south of its current range. And the green turtles in the Thames? Not a change in climate, but the visible relicts of past economics and fashion—early West Indian trade and the sophisticated gastronomic tastes of the 18th-century yuppies.

Davis shows how this knowledge is built up from the actual physical recovery of the bones through to their interpretation. There are chapters on the nature of bone and the factors influencing the accumulation and preservation of bone assemblages, demonstrating that the process of inference from bone to environment or economy is not a simple one, but one that must be experimentally and systematically investigated and tested. Davis illustrates this well in his chapters on the reconstruction of past environments and the determination of seasonality from bones and teeth.

In the second half of his book, he elaborates on these techniques through a series of chronologically organised archaeological problems—the determination of hunting behaviour, the origins of domestication, and the elaboration of agricultural uses of animals for dairy and traction purposes. Finally, Davis pulls many of these threads together with an examination of British archaeozoology.

In what must be one of the most lucid expositions on archaeozoology available, two strengths are paramount. The first is the extensive, even exhaustive use of case studies to illustrate the points made, thus showing not just the methods of

Empires to rival Rome

Atlas of Ancient America
by Michael Coe and Dean Snow, *Facts on File*, pp 248, £18.95
Nick Saunders

lively American tradition of "can do", and some immediate problems were tackled in an impressively forthright way. For example, Fraser found squatters on top of the mountain, claiming ownership of the land. He set fire to their shack!

The book describes the complicated agonies and anxieties of the years that followed. Floyd consulted astronomers, engineers and optical experts throughout the US and Europe, travelling at his own expense. Not only were there enormous problems of mounting and lens manufacture, but he and Fraser had to face criticism and jealousies of the worst kind—academic—that grew to be monstrous when it became clear that the observatory would be a success.

Edward Holden, the first director of the observatory, a West Point graduate who ran it like a military unit, was earlier a close friend of Floyd's. Rotten with envy, he turned bitterly against him and claimed all the credit for the design and construction of the telescope. Wright's book establishes that the credit belongs to Fraser and most of all to Floyd, whose efforts and achievement killed him. This is a valuable story for that reason alone. □

the subject but also many of its most important empirical findings. The second is that these examples are drawn from a great variety of contexts, from the African localities where early fossil hominids are found to the tells of Israel, from the shell middens of the Hebrides to the urban rubbish pits of medieval York.

An attractive quality of this book is its direct concern with the animals themselves. Too often, they are abused in death as much as in life, their bones being little more than a source of information about the people who killed them. Animals, though, can have their own archaeological record, and so their own ecology, evolution and pathology. The accident of being killed by a prehistoric hunter rather than a wolf can condemn a reindeer to an eternity spent in archaeology rather than palaeontology, subject to an entirely different and anthropocentric Judgment Day.

While Davis could perhaps have illustrated more the biological principles governing the lives as well as the deaths of these animals, and so the continuities with other branches of evolutionary biology, he has shown that archaeozoology is as much zoology as it is archaeology. □



Tony Morrison

FEW people realise quite the startling variety and diversity of ancient American civilisations. Unlike their Old-World counterparts in classical Greece, ancient Rome or pharaonic Egypt, the archaeological splendours of pre-Columbian America find few places in the popular imagination. This is due, in part, to the wide geographical range, number and sheer complexity of New-World cultures, which makes any meaningful synthesis difficult. Rectifying this, in an accessible, graphic and attractive fashion, is the real aim of the authors of *Atlas of Ancient America*.

From the Andes of South America through the Yucatan rainforests of Mexico to the rolling plains of North America and beyond, Amerindian societies developed a confusing patchwork of cultures. Some, such as the totem-carving inhabitants of Canada's northwest coast, attained a high level of organisational complexity based on hunting and gathering; others, such as the Aztec and Inca, achieved the status of predatory imperial states, controlling many millions of inhabitants.

All, however, shared a common and distinctively Amerindian world-view, where animals, disease, natural forces and physical environment were infused with "spirit force".

The European conquest of the Americas, during the early 16th century, was, therefore, a veritable "clash of cultures" owing its success as much to the

psychological undermining of this world-view as to the technological superiority of the conquistadores. Indeed, over a period of less than 200 years, the combined effects of disease, physical conquest and subsequent depredations led to a reduction of perhaps 90 per cent in the 40 million or so indigenous inhabitants of 1492, when the Europeans arrived.

Faced with an immense task, the authors have sensibly decided to set their atlas in an historical context, and to combine evidence from archaeology, anthropology and art history. The book is divided into six sections, on geography and environment; the first Americans; North America; Mesoamerica; South America; and the living heritage. The authors have made excellent use of "boxes" which explain such diverse topics as textiles, metallurgy, hieroglyphics, the enigmatic "ball-game" and a number of important archaeological sites.

While clearly impossible to mention all the cultures and civilisations the authors cover, some important facts do stand out. Opinions vary about when humans first arrived in the Americas, with one camp arguing for a date earlier than 10 000 years ago (possibly 30 000 years ago), while others favour a subsequent date, when the evidence is both more abundant and secure.

In Mesoamerica, the classic Maya civilisation possessed a "year" equivalent to 52 of our



Clash of cultures: just 200 years after the first European set foot in South America, the indigenous population had fallen by 90 per cent from its 1492 level of 40 million

own, and calculated a synodic month of 29.52592 days—only seven minutes different from the modern value. Their imposing pyramids, baroque style of art and hieroglyphic texts speak of a strange and often gruesome preoccupation with ritual blood sacrifice intricately associated with the movements of heavenly bodies and the nature of their dynastic society.

In South America, the quite rapid progress of archaeological investigations in recent years has revealed that Peruvian civilisation was well under way by about 2000 BC—a millennium earlier than previously thought. Huge and impressive coastal sites, with monumental architecture adorned with religiously inspired art, first flourished in the oasis-like valleys which cut across the coastal desert.

The climax of Peruvian civilisation came with the establishment of the imperial Inca state which stretched 4000 kilometres from north to south. It was knit together by 40 000 kilometres of "roads" and populated by between 8 and 12 million people. With their distinctive polygonal style of stone architecture, their transformation of the Andean environment and the success of their organisational skills, the Inca produced an empire to rival that of imperial Rome.

This is a lavishly illustrated book that contains plenty of original maps (not always as clear as they might be), and many stunning photographs. Ambitious in conception, it achieves most of its goals through thoughtful layout and careful choice of illustrations. It is attractively produced, well written and reasonably priced. A valuable contribution to the popular literature of this often neglected region of world prehistory. □

This week's reviewers

Gerald Durrell is a naturalist and writer, and the director of the Jersey Wildlife Preservation Trust. Recently, he made a TV series on the wildlife of the Soviet Union.

Robert Foley is in the department of physical anthropology at the University of Cambridge. Nick Saunders teaches archaeology at Southampton University.

THE invention of the chimney is not everybody's idea of a turning point in history. But, as Peter Brimblecombe makes clear in his race through the history of air pollution in London, it has its place in the scheme of things.

Before the chimney, pollution from the burning of wood was an indoor hazard. From cave-dwellers to the Saxons, rotting sinuses and silicosis were common, and mummified lungs dug up by archaeologists are often as black as those of 19th-century coal miners. The chimney simply sucked the smoke and sulphurous gases outside into the street and recreated the hazard outside.

In London, the chimney was a rare luxury outside the homes of the nobility before the 16th century. It was around this time that "sea coal" from Newcastle began to replace increasingly scarce wood as the dominant fuel. The combined effect of coal and chimneys was most unpleasant.

Writers of the 17th century, such as John Evelyn, complained about the growing menace of coal smoke. It corroded buildings, choked adults and, by blocking out sunlight and exacerbating an insufficiency of vitamin D,

It all changed with chimneys

The Big Smoke

by Peter Brimblecombe, *Methuen*, pp 185, £25

Fred Pearce



London's notorious smog of 1952 killed 4000 people. The sulphuric acid in the smog had pH of 1.6

helped to create an epidemic of rickets among the poor children of the city. At one time, more than half London's children suffered from the disease.

In Jacobean Westminster, Archbishop William Laud fined brewers for their use of sea coal and used the money to pay for repairs to the original St Paul's Cathedral, which was blackened and pitted by the foul air. This was an early but rare example of the "polluter-pays" principle in action. "In essence," says Brimblecombe, "we find that London in the 17th century had begun to suffer from many of the air-pollution problems we recognise today." The "big smoke" of the book's title had arrived.

Scientists gained a good grasp of the risks it posed. Michael Faraday, no less, wrote a pamphlet about the way acid air ate away the leather chairs in his London club. But "no use was made of their knowledge". By the 18th century, the naturalist Gilbert White was reporting the "dingy, smoky" appearance of London air reaching Selborne in Hampshire.

One of Brimblecombe's central observations is the failure of scientists and policy-makers to chart the source of the pollution. Between the 17th and 19th centuries, the smoky London fogs changed from being a summer phenomenon, caused largely by factories, to a winter one, dominated by smoke from domestic hearths. So, when Britain's first laws to ban industrial pollution were enacted in the reforming decades of the mid-1800s, there was widespread surprise that the London "smogs", as they became known, continued to

worsen. The worlds of Sherlock Holmes and Charles Dickens, notably in *Bleak House*, were perpetually shrouded in fog.

Despite a century of agitation by a few campaigners, it was not until the 1950s that action to banish coal burning in homes was begun. The trigger was the notorious smog of December 1952 when, astonishing as it may seem today, some 4000 people died within a couple of weeks, mostly from choking to death.

Today, researchers believe that the sulphuric acid in the smog, which may have had a pH of around 1.6, contributed as much as the smoke to the deaths, by overwhelming respiratory defence mechanisms. But the Clean Air Act of 1956, a watered-down version of a private members' bill from Gerald Nabarro, dealt only with smoke.

It required homes to convert to smokeless fuel, or switch to gas or electric heating, and ensured that the postwar generation of power stations was built outside urban areas and equipped with smoke filters and tall chimneys.

The new laws did not set any restrictions on the release of sulphur dioxide, as the sulphur-containing coal was burnt. This was born the modern peril of acid rain. The sulphur dioxide, borne from high chimneys high into the atmosphere, now falls on the countryside of Scotland or Scandinavia as acid rain.

London, says Brimblecombe, is still a polluted city. The smogs may be gone, but the city still churns out more than 100 000 tonnes of sulphur dioxide a year. And car exhausts bring a new hazard, to everything from our lungs to the contents of the National Gallery, from photochemical smogs once unique to Los Angeles.

The brown smeary haze on the horizon is no more natural than the winter fogs of yesterday. Let us hope, concludes Brimblecombe, that it does not take some horrendous Great Photochemical Smog before something is done about car exhausts. □

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Inside the Soviet trade delegation

Break-In
by Bill Graham, Bodley Head, pp 127, £9.95

Barry Fox

I ALWAYS wondered why so many helicopters fly over London's Hampstead Heath where I walk my dog. Now I may know.

Half way up Highgate West Hill, backing onto Hampstead Heath, there is a huge, four building. It houses the Soviet trade delegation in London. In the same grounds, overlooking Millfield Lane, there is a rather scruffy block of flats where many of the staff live. Security is tight, and the surrounding trees have been left to grow so that every year less and less of the building is visible. With a camera and 200-millimetre telephoto lens you can see that the building has surprisingly modern double glazing. Thereby hangs this tale.

Bill Graham, an Irish builder working in North London, says he has worked as a military policeman, a prison officer, and for the Ministry of Defence and Scotland Yard. Graham also says that, in late 1979, he was approached by Special Branch and M16, which suggested that he pitch for a job of double glazing the trade delegation building. M16 was involved because, diplomatically, the building is part of the Soviet Union.

Graham later visited the building, measured up, tendered and won the contract. His brief from M16 was to do the job as slowly as possible, while reporting back on anything and everything he saw inside. This way the security forces could build up a dossier on the 600-odd people working in the trade delegation, put real names to the faces on false passports and identify genuine job titles.

The main aim of the exercise was to bug the buildings. The plan was to build radio transmitters into the frames that Graham was fitting to the windows. The bugs would not fit into the frames so Graham took seven "raw" bugs inside, which he dotted round the building; for instance on the lectern of the conference hall and inside the men's toilet. The bugs stayed where they were, undetected for nearly nine months. Graham describes how a surveillance van, parked a mile away on Hampstead Heath, picked up the transmitted signals, clear as a bell.

Here, I started to wonder whether Graham's tale was fact or fiction. A bug must be small to conceal it from cleaners.

Transmission over a mile soaks up power. Is there really a battery that will do the job for nine months? Likewise, Graham's description of why a private commercial helicopter flew 20 times over Hampstead Heath does not ring true. While rummaging through private belongings of employees of the trade delegation, Graham found that one Soviet visitor had a "very complicated radio receiver and transmitter" and an "aerial lead which I was able to trace as far as the tree outside the window". Graham told M16 about this and the helicopter took photos. Graham says they "were so close and sharp (that) one of them showed the tree with the detail of the aerial picked out against the bark".


But, as Graham acknowledges, the trade delegation has its own official transmitter and aerials. So why use the far more inefficient method of running a wire out to a tree?

According to Bodley Head, the publisher, Graham's name is genuine and he still runs a double-glazing firm in North London. The names of the security officers mentioned have been changed. The story, says Bodley Head, is "so unlikely it's got to be true". Why then has M16 allowed the book to be published? Bodley Head does not know, but wonders if M16 thinks a success story will brighten its tarnished image. Plausible, but the book might equally well be pure fantasy.


Graham was never caught so the Soviets had no opportunity to chop off his legs. The bugs were taken out before they were found, so no tangible proof remains. If the story is false the Soviets will not deny it, because no one would believe their denial. If the story is true, they will certainly not admit it.

The technical holes in the story could be clumsy giveaways or deliberate spoofs to preserve security secrets. Graham and Bodley Head are in an all-win situation. But, either way, the book is a pretty good read.

One lingering thought remains. Bodley Head says that Graham's telephone number is ex-directory. This may deter casual readers from tracking him down, but I doubt if it will protect him from the KGB and several hundred Soviets who saw his face every day for several years. For Graham's sake, I hope his book is fantasy. □



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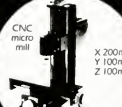
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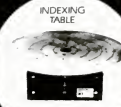
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FORUM

Wanted: professional critics of science

Critics could help to get more people involved in science. That could only be for the good, says Nicholas Russell

FOR MOST scientists, success is based on assessments of their work by their peers. They are judged, for example, by the editorial boards of journals or the specialist committees of research councils. But how do scientists judge the quality of each other's work, and is it still acceptable for them to retain the right to take decisions on who does what without the help of informed external opinion?

The existing, common-sense criteria used to evaluate scientists or their achievements are, in principle, easily understood by anyone. They would include such things as the size or complexity of the problem solved, the value of the technological consequences of a discovery, the power of an explanatory theory and the novelty or unexpectedness of a theory or discovery.

However, these criteria are difficult to apply consistently, and extraneous factors may be as important as scientific procedure in determining the quality of a piece of science. For instance, the way that science is taught, and the way that prizes are awarded to the "winners" in the scientific race, emphasise the role of heroic figures.

In contrast, there has always existed a tradition that scientific truth is bigger than its practitioners, and that today's researchers stand on the shoulders of those who have gone before. The final success of the "hero" consists of placing a keystone in an almost finished arch, and this has no significance without the pillars and the rest of the structure. In these circumstances, more credit should perhaps be given to the people who built the pillars, and their role shown to have a greater value.

It is also true that success in a scientific career may result from chance as much as from inherent intellectual or scientific gifts. Both James Watson and Peter Medawar have made the point that young scientists must choose their areas of research wisely if they are to establish a reputation quickly. They both imply that they exercised such judgment in choosing the areas in which they initially decided to work, but one feels that there must have been as much luck as judgment in their decisions. For every Watson or Medawar who found themselves in the right place at the right time, there

must be tens of others, possibly as gifted and of the same scientific calibre, who were not so fortunate.

Judgments about the quality of scientific output are also inexorably bound up with considerations relating to the status of the

in intellect or scientific gifts.

If this is indeed the case, then it argues against the continued domination of scientific decision-making by scientists. The educated citizen both can and ought to play a bigger part in discussion of the

context, direction and perhaps even the quality of science. But how are people to discriminate between good and bad science? Here scientists maintain their professional dominance. Educated citizens remain debarré from participation because they lack the necessary specialist knowledge.

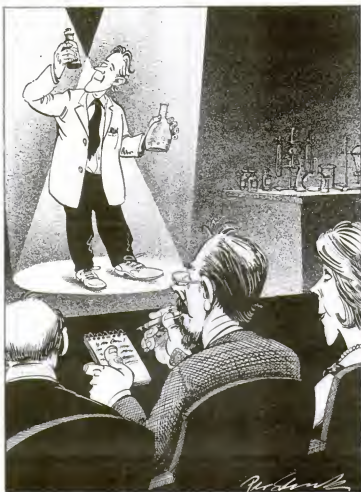
Is there any way in which an educated segment of the population could become engaged in discussion and debate about the quality of science? The practice and content of science make it a cultural activity which allows it to be compared with similar phenomena, such as the arts. One would not wish to push this analogy too far, but it is clear that there is at least one important difference between science and the arts. Some segments of the public are directly stimulated by or interested in the arts, but there seems to be little existing audience for, or need to know about, science.

Similarly, the audience uses the arts as both a source of stimulus and as recreation, processes which involve its active participation. This is not currently true of science, where the audience, outside the circle of the researchers themselves, is not expected to be active. At present, science makes little effort to stimulate, enlighten or entertain the

wider public: it merely presents the finished results for admiration and promulgation in the serious press. No wonder the audience is not interested. Until science can engage the general audience in an active way, it will remain culturally marginalised.

Taking this argument one step further, the consumer element in the arts means that there is a perceived role for commentators and critical analysts. Critics or commentators represent a professionalised tribune from the audience, conducting a dialogue with the artist on its behalf. It is accepted that this active response is an integral part of the arts: there can be little doubt that artists and writers are influenced by the work of critics. Critics play an essential role in the artistic enterprise as a whole, both for the artist and the consuming public.

Is there, then, a role for critics in science? I believe that there is. One major role for such a critical class might be to explore the



individuals, teams or laboratories involved. This may derive from criteria quite other than the quality of the work being done. For instance, one can see no rational reason why, in the 1960s and 1970s, ecology had only low status compared with molecular biology or biochemistry. It seems inconceivable to suppose that no one of quality worked in ecology and that its lowly status was therefore rationally derived from the inferior intellects and abilities of ecologists and the triviality of the problems that they dealt with.

Most impartial observers would seek to explain the relative status of particular disciplines in historical or sociological terms, rather than in the calibre of the science and the scientists. Rather obviously, therefore, quality of scientific achievement may have as much to do with accidents of timing, opportunity, personality and so on as it does with differences

possibility that there do exist intrinsic criteria for judging quality in science. They could begin by looking closely at some of the criteria by which scientists are already judged. They could also usefully question whether there is an *aesthetic* in science and its procedures. By *aesthetic* I do not mean beauty in an artistic sense. Art has various sets of aesthetic principles but they cannot be applied directly to any nonartistic activity. By the same token, I do not mean judgment of scientific writing by the canons of literary criticism. Scientific writing which passes these criteria may exist, but the style or elegance of a piece of science would not reside there. Good science may or may not be marked by the intrinsic satisfaction of some aesthetic criteria: as yet we cannot tell because so far no one seems to have attempted to lay down any rules which might help us to decide either way.

In mathematics, the concept of elegance is well established, and implies the selection of the "best", according to a set of aesthetic

criteria, from a variety of possible solutions to a problem. Fitness of means and economy of effort in arriving at the solution are examples of the factors involved. Norman Smith, a historian of technology, has explored the concept of elegance or aesthetic in engineering and lists a group of criteria for assessing this property in technological designs and solutions. They include such things as economy of means and appropriateness of materials together with such properties as self-regulation and the degree to which an engineering solution exploits (in the sense of going along with) an effect inherent in the problem rather than trying to evade or overcome it.

Whether a similar set of aesthetic points exists within the sciences and, if it does, what purpose or use it might serve, remains for future critics to decide. I merely propose that this is one line of development for opening science up to wider cultural understanding and debate. □

Americans, and American academics are paid for only nine months of the year. They are expected in the remaining three months to work for industry or to obtain the large research grants that are available to them to carry on their basic research.

In Britain, the system is not arranged that way. In British academic geology, a great deal of our so-called vacation is taken up by the supervision of students, both undergraduate and postgraduate, which is one reason why our degree courses are so much shorter than everybody else's. What is more, grants are much more difficult to come by.

What does the oil industry want from academic geologists? It wants basic information about rock structures, about sedimentary environments and about fossil identifications for correlation. In other words, it wants a routine service. When it does hand out jobs to academics, these are often simply a matter of getting some straightforward work done on the cheap, such as measuring sections in unexplored terrains. I'll certainly do things for industry if they interest me, but I'm damned if I'll be just a cheap subcontractor. I certainly encourage students to work in general areas that will equip them for work with oil companies later (when they'll soon be paid more than I am).

It seems to me that industry would be much better advised to go to the universities rather than to expect academics to go to them. Who is to say what is going to be the next exciting area, the next useful tool, the next breakthrough in studying the Earth and its history? That remarkable Victorian geologist, Henry Sorby, was years ahead of his time when he made thin sections of rock that he could study under the microscope. The Victorians used to make fanciful arrangements of different microfossils to look at, as in one of their kaleidoscopes. Nothing could seem further from practicality, yet nothing has proved more useful to the oil industry than microfossils in correlating its boreholes.

The oil and mining industries should finance universities to study the geological structure of Outer Ruritania, even if they have no hint of any natural resources that may be there. Nothing is irrelevant in geology. Even the mating habits of ancient king crabs—I call it palaeopornography—are relevant to the interpretation of ancient environments and, therefore, to the search for oil.

William Smith, the "Father of English Geology" (who was a bachelor all his life), was said by a German writer to have "opened the book of Earth history". A contemporary said of him that, "in his indescribable contempt for money, he communicated his discoveries to anyone who sought information". Though I would not pretend that academics despise money, there is a fundamental difference between university geologists, who will talk to you ad nauseam about whatever happens to interest them at the time, and industrial geologists, who are constantly looking over their shoulder at management. □

Mortarboard or hard hat?

Derek Ager ponders the gulf between academia and industry

WE ARE constantly being told in the universities to relate our work more towards the interests of industry. But have we got this the right way round? As a geologist, my industrial cousins are all in the oil and mining industries, especially, these days, in the former. Any university geologists worth their salt could probably earn three or four times their salary in industry. So why do they do what they do?

First, there is the rewarding and stimulating environment of teaching and encouraging new minds, especially those of research students. Secondly, there is the excitement of your own basic research in whatever field happens to take your fancy, without the threat of being switched to something completely different at the whim of an employer who is more concerned with gambling than with truth. Thirdly, there is the wonderful international fellowship of fellow researchers who are not constrained by the secrecy of competing companies. This is the way in which the really important new ideas originate in every branch of science.

When I came out of the Army at the end of the Second World War, I swore that I would not give orders or take orders any more. I often say to myself those wonderful words from *Linden Laë*:

I don't fear a peevish master
Though no man may heed my frown.

For that privilege I have been content to



Spot the academic. Despite the image, many seemingly arcane areas of academic research have proved to be vital to industry

accept a lower salary than I might have earned elsewhere.

Most industrial research is pretty humdrum. In the oil industry, it means the endless logging of boreholes and sitting in an office analysing the seismic profiles obtained by geophysical traverses. The oil industry is, of course, dominated by the



Mark Evans

Derek Ager is professor of geology at University College, Swansea.

Towards bigger and better mirrors

Ian Anderson reflects on the pioneering work of Roger Angel

SCIENCE and football stadia might sound like strange bedfellows, but the connection has been made in fateful ways at least twice—once during the Second World War and again today. In 1942, the nuclear age was born under the stands of the University of Chicago's Stagg Field, when metallurgists developed a way of producing plutonium-239. That development was essential to the Manhattan Project. Today, at the University of Arizona in Tucson, a scientific revolution of a far more benign kind is taking place beneath the seats of a football stadium.

The Arizona Stadium is home to both the Wildcats—the university's football team—and to astronomer and telescope builder extraordinaire, Roger Angel.

Angel has taken over what was once an undercover car park on the eastern side of the 57 000-seat stadium. The sides have been built in, of course, providing a laboratory 40 metres long, 15 metres wide, and 20 metres high. It is called the Steward Observatory Mirror Laboratory. Here, Angel and his team of scientists and engineers are building what many are saying will be the next generation of mirrors for reflecting telescopes around the world. They have applied novel techniques—including a spinning oven, 10 metres wide—to some old ideas to make mirrors for telescopes that will view the skies in both the optical and infrared wavelengths. The goal is a single mirror with a short focal length that is 8 metres across.

"We needed somewhere high enough and wide enough to manoeuvre large mirrors," says Angel, when asked to explain the curious choice of a site.

If all goes according to plan—and that is by no means certain given the pioneering work that is being done—the first large mirror should be cast in 1989. After that, two 8-metre mirrors a year can be expected until a new technology emerges. Along the way, the team is making smaller mirrors. These will be used in telescopes that are already planned or are being built.

Of all institutions, the Vatican is Angel's first customer. The Vatican Advanced Technology Telescope, consisting of a 1.8-metre mirror spun in Angel's laboratory two years ago, will be the first reflecting telescope at the new Mount Graham International Observatory in Arizona. Plans for the observatory are running into stiff opposition from environmentalists, but a scaled-down version of what the university would like to see on the mountain is expected to gain approval from the US Forest Service by September.

Angel is a physicist by training—first at

the University of Oxford then at the University of Columbia. He has been in Tucson for 12 years. It was a realisation that applied physics was needed if reflecting telescopes were ever going to get any bigger and more efficient that drew Angel to his present line of work.

He uses strong words to state the problem: "Mirrors for optical telescopes have been a disaster. They are too small and too



Mirror image: Roger Angel with a 1.8-metre honeycomb

heavy with too much thermal inertia. [That is, they are slow to adjust to changes in air temperature.] And their focal lengths are too long." The result, says Angel, is mirrors that are cumbersome, expensive and limited in sharpness of image.

The 5-metre Hale Telescope—designed in the 1930s and commissioned by Mount Palomar in southern California in 1948—remains the world's largest working reflecting telescope. The Soviets opened a 6-metre telescope at Mount Pstakuhov in 1976, but Western astronomers believe that the mirror may have warped because of its massive size and weight. Stiff, lightweight mirrors will be needed and that is Angel's mission.

"It's just incredible to think what's happened to the rest of science in the last 50 years, while our ground-based telescopes haven't gotten any bigger," he says. "People in optical astronomy got into a very bad habit of using whatever telescopes and instruments were offered them." Instead, astronomers should build their own, like Herschel and Newton once did.

In Arizona, the Multiple Mirror Telescope, commissioned in 1979, and sitting atop Mount Hopkins, is regarded as the key to today's developments. "For the first time since Palomar, physicists got involved with

designing an optical telescope from scratch," says Angel. The university inherited six 2-metre mirrors from a satellite project that the US Air Force never flew. By putting the mirrors in a cluster, astronomers were able to build the world's third largest telescope with an aperture equivalent to 4.5 metres.

Angel and his colleagues from Steward Observatory, in particular Neville Woolf and Peter Strittmatter, realised that squat telescopes with up to four large mirrors of very short focal length could gather far more light than any single mirror and at far less cost. Today's telescopes can do no better than a focal length of $f/2$, which means that they focus incoming light at a distance twice the diameter of the primary mirror. Angel's team is trying to reduce that to $f/1$.

However, polishing an $f/1$ mirror is no easy matter because of the deep curvature involved. Angel's technique involves casting the mirror by rotation, which means that centrifugal force automatically creates the desired parabolic shape. The Hale mirror, and others like it, start off as flat pieces of glass that must be carved out. To do this for an $f/1$, 8-metre mirror would require the removal of 20 tonnes of glass—a 12-month job, according to best estimates. Angel's crew has devised a computer-controlled polishing tool that can be adjusted up to 1000 times a second as it moves over the surface.

However, the most spectacular part of the technology is the 120-tonne steel furnace, designed by chief engineer, Larry Goble. It will rotate at up to 12 revolutions per minute, the speed of the rotation determining the curvature and hence the focal length. Heating coils within the lid, walls and base of the furnace will raise the temperature to as much as 1200°C.

Inside the furnace is a pan. Chunks of borosilicate glass are placed in the pan. Over two days, the glass will melt and flow over and between a honeycomb-shaped mould. Another three to six weeks will be needed for the glass to anneal and cool (the Hale mirror took 12 months!). The hexagonal plugs used to create the honeycomb structure are then flushed out using a stream of pressurised water.

The result is a thin surface of glass backed by honeycombed rigs. It is strong, lightweight and easily ventilated. Astronomers first proposed a honeycombed structure for mirrors in the 1920s. Only now is the technology available to achieve it.

A big test will come in October. The laboratory will cast a 3.5-metre mirror which, if it works, will be used for the new Apache Point Observatory in the Sacramento Mountains of New Mexico. Next year, Angel plans to scale up to a 6.5-metre mirror that, ironically, will be used to replace the small mirrors of the Multiple Mirror Telescope (using a single mirror on the existing frame is the best way for the telescope to increase its size). After that there is talk of two 8-metre mirrors for the "two-shooter" or binocular telescope that the University of Arizona would like to place on Mount Graham. The telescope, which will have a light-collecting area equivalent to 11.3 metres, will, for a time at least, be the largest reflecting telescope in the world. □

An unhappy ending

Donald Gould came across a grim reminder of man's inhumanity

THE depressing weather in June was well matched by a steady flow of equally depressing news items, many of them rehearsing man's inhumanity to man. But one of the grimmest of these sad reminders of *H. Sap's* barbarity earned no mention at all in two out of the four "quality" papers I feel obliged to scan each day, and the other two tucked it away under "News in Brief", thus dismissing it as a matter of some slight interest, but no real importance.

The story in question was a Reuters' despatch from Texas, describing the execution of a 28-year-old named Elliot Rod Johnson. Johnson had been condemned to death for the murder of two men who were killed when he raided a jewellery store.

Nothing unusual about that. Murder in the course of robbery is commonplace in the US, and so too, now, is the execution of those convicted of the crime.

What made this particular act of retribution newsworthy in Reuters' eyes were the unusually macabre circumstances surrounding the deed. Texas is one of the states which have opted to rid themselves of undesirables by the intravenous injection of a barbiturate followed by a shot of poison which stops the heart. This obscene prostitution of the skills and tools of the healing trade is revolting enough when all goes according to plan, but on this occasion the official assassins made a right hash of the job.

They spent 35 minutes prodding around before they could find a vein into which they could slide the catheter through which the chief executioner (who operates, I understand, from behind a screen) would introduce the lethal mix.

This wicked shambles was witnessed by the Texan Attorney General, Jim Mattox, who afterwards explained that Johnson had ruined all his superficial veins by injecting himself with drugs and that's why the executioners had experienced such trouble with their task.

How embarrassed the poor chaps must have felt, what with the AG, and no doubt a clutch of reporters as well, watching and waiting impatiently for the *coup de grace*. Clearly that 35 minutes of frightful manoeuvring wasn't really their fault at all. You might almost say that Johnson had brought it on himself.

Wait a minute, though. I seem to remember that in the bad old days (the good old days, too many of my compatriots would say), when we in Britain indulged in judicial murder, the hangman would take great pains to ensure that his dawn duty proceeded without a hitch. Not only did he carefully check his killing machine, but, the night before D-day, he would take a discreet peep through the grill in the door of the condemned man's cell, expertly sizing his victim up, and calculating to a nice degree the drop that would be needed to ensure a good, clean dislocation of the neck without producing actual dismemberment (which could only prove distasteful to all concerned).



So I just wonder whether the gentlemen in Texas couldn't have shown a similar pride in their job. It would, surely, have been a simple matter for somebody in the team (perhaps the friendly prison doctor) to have discovered in advance (and without

making too much of a grisly performance of the task) whether or not the unfortunate Johnson possessed the kind of veins that would make it possible to achieve his quietus with reasonable efficiency and despatch. Had this been done, I can't imagine that even the most obtuse and hard-bitten authority would have risked the shameful and shaming interlude of death-chamber torture which in fact occurred. Some other way of dealing with the prisoner would have been found.

But it was not done and, as a result, Elliot Rod Johnson earned himself a brief, ugly obituary in the trifle columns of *The Guardian* and *The Times*.

However, the true importance of the Texan fiasco lies not so much in the cruel treatment suffered by one admittedly wicked man (vile though that was), but rather in the manner in which it underlines the greatest objection to judicial execution.

Capital punishment, however neatly and "humanely" carried out, demeans, brutalises and dehumanises all those involved in the frightful deed, and thus, also, the whole of the society they serve.

I hope the members of our new parliament remember this next time the hangers and floggers attempt to put the clock back in this (we like to think) most civilised of lands. □

Maiden speeches make their mark

The Commons gets off to a flying start

THISTLE DIARY



Tam Dalyell MP

THE CROP of maiden speeches so far—and three of them on the opening day—is most promising. In 1964, we had only one such speech on one day of the Queen's Speech. It was Harold Wilson's first day as Prime Minister, and the newly elected member of parliament for Buckingham, a not-so-shrinking violet, announced himself in the Commons at 2.30 pm as "Captain Robert Maxwell MC". Alas, he is no longer an MP, but the mists of time have not exactly reduced him to obscurity.

In this year's batch, Tony Worthington (Labour Party representative for Clydebank) argued the case for more sectoral planning in the engineering industry, and went on: "There is no sign that other developed countries are willing to give as low priority to manufacturing industry as the government is with its over-reliance on the service industries."

Graham Allen, the Labour representative for Nottingham North, deplored what has happened since the last general election, with the demise of the pits at Babbington and Hucknall, Thorn EMI and the Royal Ordnance Factory at Chilwell, the way in which Raleigh cycles had become a shell of its former self, and the "restructuring" of Boots the chemists. Allen concluded: "Impatient as I am as a newcomer to parliament—and if I had a desk I would bang it—I wish to avoid the

pitfall of William Cobbett who made his maiden speech early in the 19th century after listening to just one debate and pronounced: 'Mr Speaker, it appears to me that since I have been sitting here, I have heard a great deal of vain and unprofitable conversation.'

The first maiden speech of the new parliament, by David Blunkett (Labour member for Sheffield, Brightside), has been highly praised. Much is written about the remarkable achievement of a man who has been blind from birth. I believe, however, that this emphasis on his handicap is to the detriment of his achievement as a powerful councillor running the great City of Sheffield. I sit next to him on the Labour Party National Executive, and I admire the quality of his mind. (I must learn, though, not suddenly to stretch my legs and buffet Ted, his guide dog, with my foot. When I do so, the beast looks at me reprovingly, but nothing like as reprovingly as my human colleagues on the NEC!)

MOST FORMIDABLE of all the committees of the Commons is the Committee on Privileges. That I know from first-hand experience! I appeared before the committee exactly 20 years ago, because I had talked too freely to Lawrence Marks of *The Observer* about a visit of the Select Committee on Science and Technology to Porton Down. My arraignment at the Bar of the House actually brought that particular practice for such supposed misdemeanours into disrepute. However, for me it was a dreadful experience because I was interrogated by the "Prosecutor of Nuremberg"—Elwyn Jones, then Attorney General, had been just that.

► But what, you may be wondering, are the guiding rules of such a committee? First, the committee says that national security can be assessed only by ministers, because only they have access to all the relevant information. If a senior minister advises the Speaker that disclosure of certain information would be damaging to national security, that may be accepted. Whether the House decides to take action following such advice is another matter.

Secondly, the Privileges Committee says that any restrictions that might be imposed on disclosure in the House of information relating to national security must be imposed by the House itself. This is not something which the House should entrust to the courts.

Thirdly, the committee says that the procedures and practices of the House must continue to enable members to be briefed by outside bodies and persons, and to brief each other on matters that are, or may come before the House. In some cases this will involve members being given information in confidence—in select committees for example—relating to national security. The possibility of damaging disclosures in



rare instances must not be used to deprive all members of proper access to information needed for the performance of their parliamentary duties. These guidelines seem to me to be sound.

The committee has just reported on the Zircon affair. Now, I find it unsatisfactory that, five months after they raided the BBC in Glasgow to get hold of Duncan Campbell's dossier on the spy satellite, the police have not charged anyone. Nor will they, for the simple reason that there was no leak and, therefore, no leaker. Campbell has based his film about Zircon on his own knowledge of physics and on information in published sources. Had it really been a security threat to Britain, the Ministry of Defence would have acted within a day of hearing from its old chief scientific adviser, Sir Ronald Mason, who Campbell had asked about Zircon. The Zircon affair was really about putting pressure on the Beeb.

GENERAL ELECTIONS apart, few things stir MPs to passion more than our own domestic arrangements. The future of Parliament Square is a burning issue. A public exhibition on the proposals, which would result in the closure of part of the square to traffic, and the establishment of a pedestrian precinct, is now under discussion in the corridors of the House of Commons. If you want to have your say, you have until the end of this week to get to the Crypt of the Banqueting Hall, and express your views. □

KENNETH BAKER,

political supremo at the Department of Education and Science, is in fighting mood this parliamentary session. Addressing a scientific awards ceremony sponsored by IBM last week, Baker first extolled the virtues of private sponsorship in education and research. British industry, he said, is not doing enough to back the white coats.

Baker followed up this brief voyage into the enterprise economy with some stern words for assembled scientists and scribes. Your job, he maintained, is to explain the benefits of science and technology to society. Unless you do that, "you are no use to the people out there and no use to me".

We have been warned. □

ALAN SUGAR, boss of Amstrad, was also in a mood last week to blame things on the press. Rumours that his PC 1512 machine, introduced last autumn, is not doing as well as expected prompted Sugar to have a go at both securities analysts (the people who advise investors on what shares to buy) and the computer press.

Sugar believes that bad press notices can close computer production lines as easily as they can Broadway shows. "The power of the pen is quite strong," he opines. "If you launch a product in the spring you might find all the journalists in a nice frame of mind."

What riles the video and computer magnate is the power wielded by electronics securities analysts, whom he claims rely on the fickle journalists for their information. "An analyst speaks to a journalist, walks into Dixons in High Street Streatham ... and some chap sells 50 million pounds worth of stock."

For all his complaints, Sugar readily admits that his latest machine, the PC 1640 is an amended version of his first computer. "We have learnt a lot from what you have written in your magazines," he reveals. □

LAST WEEK, a small party of media folk assembled at Northolt Airport for a flying visit to the Merlewood Research Station, the Cumbrian outpost of the Institute of Terrestrial Ecology.

The transport laid on was a Piper Chieftain, which the Natural Environment Research Council uses for its remote-sensing work. As a passenger plane, it falls well short of Concorde-style opulence.

As they boarded the plane the intrepid travellers were handed press packs which contained a strikingly honest letter. It said: "Welcome aboard the NERC aircraft. As you see it is not used primarily with passenger comfort in mind, but we hope you will enjoy your flight."

Prophetic words.

One hapless back was violently sick before the plane landed at Furness airport in distant Cumbria. Wise fellow, he let the train take the strain for the return leg. □

BRITAIN'S northerly offshore islands are well used to invaders. Last week a ragbag of anti-nuclear campaigners from Europe and mainland Britain turned up in Lerwick, capital of the Shetlands. A two-

FEEDBACK

day conference was being held there to focus opposition to the plan to build the world's largest fast reactor nuclear reprocessing plant at Dounreay.

Feedback is sure that the presence of Friends of the Earth, Greenpeace and the Scottish Campaign to Resist the Atomic Menace was viewed as a welcome gesture in the struggle against the Dounreay project. Just how committed those groups are to the cause in question is something of a moot point.

Feedback recalls that all of them boycotted the public inquiry into the project when it opened on a wet day last April in Thurso, one of mainland Scotland's less prepossessing burghs. The locals were left to soldier on with little help from the big battalions of the environmental movement.

Clearly, the prospect of a few days in the far north when the nights are short and the days rather pleasant concentrated minds wonderfully. □

NEW SCIENTIST'S publisher was wandering around the office last week, looking for copies of our most recent issue. Unfortunately, he couldn't lay his hands on enough spare copies to make up for the 700 copies that British Rail had managed to lose—so we apologise to readers in Canterbury, Herne Bay, Whitstable, Margate, Broadstairs, Three Bridges and Brighton.

It's no use asking Feedback for copies—we can't get hold of any either.

A small reward for anybody who finds the missing batch. □

ENIGMA

No 418

Let us divide

by Eric Emmet

IN THE following division sum each letter stands for a different digit:

$$\begin{array}{r} \text{g x) } \text{t x b m t} \\ \underline{\text{t k p}} \\ \text{g t m} \\ \underline{\text{a b m}} \\ \text{a d t} \\ \underline{\text{t p y}} \\ \text{t m} \end{array}$$

Re-write the sum with the letters replaced by digits.

A £10 book token will be awarded to the sender of the first correct solution opened on Thursday, 23 July. Please send entries to Enigma No 418, New Scientist, Commonwealth House, 1-19 New Oxford Street, London WC1A 1NG. The Editor's decision is final. The winner of Enigma No 415, "Buses galore", was K. Beurl, of London.

Answer to Enigma 415

Buses galore

Ten buses

LETTERS

Model evolution



As is common with long suffering parents the world over, I have endured episodes of the robotic cartoon series *Transformers*. I was somewhat startled upon having a small hermit crab placed in my hand recently and my five-year old son solemnly intone: "It's really a helmet crab shell Dad, watch it transform into a crab." Is this overexposure or unadulterated Darwinian observation?
 John Glaister
 Fisheries Research
 Northern Territory
 Australia

Initial error

Whilst reading *Ariadne* (18 June, p 104), I was dismayed to read an article about ABM Food and Brewing group. The article is incorrect, the advert concerned refers to Associated British Biscuits not ABM Food and Brewing group.
 W. K. Blow
 ABM Brewing & Food Group
 Woodley
 Cheshire

Chemical backlash

First, may we congratulate *New Scientist* for its excellent forward-looking editorial on projecting science as dynamic and exciting (18 June, p 26). Secondly, may we bemoan yet another depressing, negative, inaccurate and

misleading article by John Emsley, "A degree too difficult?", in the same issue (Forum, p 69). The contrast could not be greater.

There is no doubt that chemistry as a degree subject is less popular than many in industry and in academic life would wish. However, we should advertise and build on those bright signs which do occur. For example, applications to read chemistry at university are up on last year. There were no fewer than 15 500 UCCA applications for courses starting this October (a 5 per cent increase), so how does Emsley construe this as "the continuing decline in the numbers of applicants to university chemistry departments"?

Under the title "Decline of chemistry", Emsley criticises British academics for not writing chemistry textbooks (Review, 30 April, p 63). In this age of the market economy, any top-level scientist who writes a book should be congratulated. By any standard, the financial return is poor. A little research on his part would have told him that quite a number of books by British authors are in the pipeline. Blackwell Scientific Publications has 14 either very recently published or under contract.

In his latest writing, Emsley argues that chemistry minus mathematics is the way to go, apparently to increase its appeal. This would be disastrous. Some students probably do choose chemistry because it contains less mathematics than some subjects, but this is no reason to alter the nature of the subject itself. Is chemistry really perceived as "hard, boring and too heavy on mathematics"? We think not, and such suggestions compound the problem of interest in chemistry rather than contributing to its future.

Ironically, for many of the best chemistry graduates who go into accountancy and computing, a numerate background is their main asset! We believe Emsley's criticism of mathematical content is a side

issue; to include an assertion that "the structure of the water molecule, H_2O , cannot be explained by theoretical chemists" is farcical. This is irresponsible journalism.

So, to return to the theme of your editorial, it is necessary to convince those in power of the economic worth of teaching and research in chemistry and, we add, to reward chemists with salaries in line with their contribution to the economy. This will be achieved by "selling" the subject to the government and to the customers. We hope that John Emsley will play his part and put pen to paper in support of a bright, exciting future for chemistry.
 Peter Sarre, John Simons
 Nottingham

Down to business



I am consistently intrigued by the brassiness demonstrated by *New Scientist* when the subject of public expenditure is discussed.

"No one is willing to compensate the scientific organisations for fluctuations in exchange rates" (p 10). The Treasury will not stump up the cash. "The solution is obvious. The government has [my emphasis] to insulate large science projects from currency fluctuations."

The attitude that lies behind this phraseology is all too typical of both the scientific and educational

establishments. As a businessman who has to cope with the vagaries of exchange rates and who is not the recipient of large sums from the public purse, I find the constant whingeing of scientists and their spokespersons boring and repulsive.

More important, it is counter-productive. Supporters of increased spending on R&D are not inclined to root for people who seem to believe they have a prescriptive right to opt out of the problems that beset the rest of us, especially when they depend on the taxpayer for their existence.

Patrick F. Friermer
 Interactive Information Systems
 London EC1

Millet miner

Marcus Matthews's article on the millet head miner (18 June, p 47) gives an excellent account of an insect which farmers in the Western Sudan now consider causes the greatest annual losses in millet. I would, however, like to indicate an alternative control strategy that I tested in the Western Sudan.

Spraying pesticides against the pest at heading gave excellent control of the pest but the yield increases resulting from applications were of the order of 10 per cent and not cost effective considering the low price paid to farmers for millet. Using Triple super phosphate fertiliser at 20 kilograms per hectare resulted in a 50 per cent increase in yield, reduced the time to 50 per cent flowering by between 10 and 20 days and reduced the incidence of the pest by 25 per cent.
 David Hughes
 London N22

We welcome short communications and reserve the right to edit the longer ones. Write to: Letters to the Editor, *New Scientist*, Commonwealth House, 1-19 New Oxford St, London WC1A 1NG. Or send to: Telecom Gold Box 83: NSM005.

GRIMBLETON DOWN

I DON'T WANT TO GO TREEM, AND MAYBE IT WON'T LIKE IT IN THE USA BUT I NEED TO WORK IN A...



PROPERLY FUNDED, STIMULATING ENVIRONMENT WITH A THRILLING TEAM, AND BIOCENTRIC SAY THAT THEY—

I HOPE THEY ALSO TOLD YOU OF THE STREET VIOLENCE, DRUGS, LUNATICS WITH GUNS, HIGH COST OF MEDICINE—



OH COME OFF IT, TREEM, IT'S BECOMING JUST LIKE THAT HERE!

EXACTLY! GIVE US TIME, WE'RE SLOWLY GETTING IT RIGHT!



Bill Tidy

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**EXPERIENCED SCIENTISTS AND NEW GRADUATES
WALTHAM ABBEY, ESSEX**

Royal Ordnance plc is a major supplier of defence equipment both to the UK armed forces and over 50 countries worldwide. Our products are also integrated into major equipments manufactured by other defence companies in the UK, Europe and USA.

The R&D Centre at Waltham Abbey is our centre of expertise on gun and rocket propellants, energetic ingredients and defence-related polymer applications for the Land Weapons and Naval, Air and Engineering Divisions.

We are looking to recruit highly-motivated scientists to join our expanding R&D teams working on new and existing applications in all these challenging areas.

If you have a good degree in a scientific discipline and/or several years' relevant experience, or are graduating this year, we would like to hear from you.

Salaries are commensurate with qualifications and experience.

Attractive benefits include a contributory pension scheme and generous holidays.

For an application form, please telephone 0892 713030 ext 334 or send your cv to Elsa McFarlane, Personnel Department, Royal Ordnance plc, Sewardstone Road, Waltham Abbey, Essex EN9 1AY.

Royal Ordnance plc is an equal opportunities employer.

**ROYAL POSTGRADUATE
MEDICAL SCHOOL
(University of London)
Hammersmith Hospital
LECTURER IN CHEMICAL
PATHOLOGY**

Applications are invited for the post of Lecturer (non-clinical) in the Department of Chemical Pathology at the Royal Postgraduate Medical School.

The Lecturer will have an appropriate higher qualification and training and experience in chemical pathology with particular reference to radioimmunoassay. In addition to sharing the direction of the immunoassay section within the Department with other colleagues, the person appointed will promote the development of novel hormone assays for clinical use. On the research side, he or she should be expert in the endocrinology of calcium regulating hormones, especially those from the calcitonin genes. Experience and expertise in cell culture including cell microinjection and time lapse cell video recording is essential. There is a small research unit within the Department concerned with the cell biology of bone cells and the Lecturer would be expected to work with this group in addition to the essential academic activities of teaching and research in chemical pathology.

Applications (six copies of cv and the names of three referees) should be sent to the Deputy Secretary, Royal Postgraduate Medical School, Hammersmith Hospital, Du Cane Road, London W12 0HS, from whom further particulars may be obtained (Tel 01-740 3203). Candidates wishing to discuss the post further should contact Prof I. MacIntyre (Tel 01-740 3227). The closing date for receipt of applications is 30 July, 1987. Ref AC/LECT.

**THE UNIVERSITY OF
MANCHESTER**

**Department of Cell and
Structural Biology**

RESEARCH ASSOCIATE

A MRC funded research group (Chemical Morphology, Prof J. E. Scott), working on structure-function relationships in connective tissues, has a vacancy for a chemist/biochemist with skills or interests in collagen/glycoprotein-proteoglycan fields. A knowledge of peptide fractionation and characterisation techniques would be an advantage. Salary range £9085-£14825 pa. Superannuation. Cv and relevant information to Prof L. E. Scott, Chemistry Building, The University, Manchester M13 9PL.

ROYAL ORDNANCE

Defence systems, sub-systems and components

**THE UNIVERSITY OF SUSSEX
RESEARCH FELLOW IN
EXPERIMENTAL LOW
TEMPERATURE PHYSICS**

Applications are invited from qualified men and women for a three year appointment commencing on or about 1 October 1987, for work on Heavy Fermion materials.

Salary within the Grade 1A £9305 to £14 825 pa.

Applications Professor M. Springfield, Physics Division, University of Sussex, Brighton BN1 9QH, England.

FRUSTRATED INVENTORS

A Public company involved in financing medical and related inventions is currently seeking projects of commercial viability.

The company provides finance of up to one million pounds per project as well as business liaison and expertise.

Box Number D985

Polymer Chemist

for Coatings Research and Development

Negotiable Salary

North East

Our client is a leader in the high technology surface coatings market and is renowned for scientific and technological innovation and achievement. To maintain this enviable position and continue their commitment to a sustained level of growth, the Company plans further expansion of its R & D function.

A unique opportunity currently exists for a talented and innovative Polymer Chemist to join the Company's Polymer Development Laboratory and play a key developmental role in the design, synthesis and testing of novel polymers for use in a wide range of heavy duty and industrial coatings. The position provides an exciting opportunity to work closely with coating development laboratories in both the UK and overseas with new product development being related to specific market opportunities.

Probably aged 25-30, you will have a good honours degree preferably in a polymer related discipline and have relevant experience in industry or academia. A sound background in laboratory work is essential linked to a record of creative

achievement ideally in the field of polymer synthesis. A higher degree or PhD would be a distinct advantage.

In addition to the opportunity of working in a challenging and stimulating environment, a competitive salary and comprehensive benefits package will be offered including relocation assistance to an area containing some of Britain's most beautiful coastline and countryside, reasonably priced housing to suit all tastes and excellent travel links.

Austin Knight Selection has been retained to handle initial response. Interested male or female candidates should contact Raymond Woods, Consultant on (091) 261 4044 (office) or (091) 489 2231 (evenings after 7.00 p.m.); or write to him at Austin Knight Selection, Erick House, Princess Square, Newcastle upon Tyne NE1 8ER quoting reference NS145.

Austin Knight Selection

AFRC INSTITUTE OF FOOD RESEARCH

Reading Laboratory

Applications are invited for a two year appointment to work on an EEC funded project concerned with the physical properties of butterfat. This project seeks to identify the processing factors which are responsible for variation in the thermal properties of butterfat fractions and to examine means of achieving specifically directed modifications of fractions using chemical or biological transformations. The work will involve the application of a variety of techniques including capillary GC, HPLC, differential scanning calorimetry and pulsed NMR spectroscopy, and experience in these will be an advantage.

The appointee will be responsible for overall project management, supervision of a technician providing support to the project, liaison with industry and preparing reports.

The appointment will be as Higher Scientific Officer (£8733-£11 765).

Minimum qualifications: degree, HND or HNC in relevant subject, with five years' post-qualifying experience.

Application forms and further details from Personnel Officer, Institute of Food Research, Reading Laboratory, Shinfield, Reading RG2 9AT.

Closing date for applications 24 July, 1987.

THE UNIVERSITY OF MANCHESTER

CHAIR IN GEOLOGY

Applications are invited for the above post which becomes vacant through the impending retirement of Professor W. S. MacKenzie. The other chair in the Department of Geology is held by Professor Zussman.

Applicants should have active research programmes in any of the fields of Physics and Chemistry of Minerals; Geochemistry; Petrology, and the person appointed will be expected to play a major role in establishing in Manchester University a new high level 'Centre for Research in Earth and Planetary Sciences'. Along with this development, existing interdisciplinary research and teaching links will be strengthened, eg with Departments of Biological Sciences, Chemistry, Engineering, Geography, Metallurgy and Materials Science, and Physics.

It is intended that the position should be taken up as early as possible in 1988.

Applications (one copy suitable for photocopying), giving full details of qualifications and experience and the names and addresses of three persons to whom reference may be made, should be sent no later than 27 July, 1987 to the Registrar, the University, Manchester M13 9PL, from whom further particulars may be obtained. Please quote Ref 155/87/NS.

SOFTWARE ENGINEERS TECHNICAL PROGRAMMERS MATHEMATICAL MODELLERS

Numerous vacancies are available predominantly in Southern England, for graduates, with at least a year's experience, or postgraduates. Applications are also invited from candidates with higher degrees.

Experience in the following languages is particularly advantageous:

FORTRAN • ALGOL • C • CORAL • ADA • PASCAL • ASSEMBLY LANGUAGES

Please write with full career details, listing a telephone number for contact, or telephone for an Application Form.

AMES PERSONNEL, 4A BIRKHEADS ROAD, REGATE, SURREY RH2 0AR
TELEPHONE: REGATE (0737) 222491

AMES PERSONNEL

UNIVERSITY COLLEGE AND MIDDLESEX SCHOOL OF MEDICINE

Department of Medicine TECHNICIAN

required for exciting work on the molecular basis of inherited disorders of mineral metabolism, using gene probes with recombinant DNA techniques. The appointment is on the MLSO scale £7569-£10 187 (under review) for 15 months, and would suit a new graduate, preferably in Biochemistry. Applications in the form of a cv with the names, addresses and telephone numbers of two referees should be sent to Prof J. L. H. O'Riordan, Department of Medicine, Thorn Institute, Middlesex Hospital, Mortimer Street, London W1.

CROYDON HEALTH

AUTHORITY MISO's (Clinical Chemistry) MAYDAY HOSPITAL

We seek a suitably qualified person for this vacancy in a busy, well equipped District Laboratory. Excellent facilities exist for further study.

A single-discipline on-call system operates.

For further information, or to arrange an informal visit, contact, Mr P. Brooks Chief MISO, Tel 01-684 6999, Ext 3420.

For application form and job description contact Mayday Hospital, Mayday Road, Thornton Heath, Surrey, Tel 01-684 6999, Ext 3530 or 3757.

Quote 839.

SCHERING

Head of Crop Sciences

Chesterford Park Research Station

Schering AG, West Germany, is a major force in the chemical industry worldwide. Within the UK our interests include pharmaceuticals, industrial chemicals, electroplating and chemicals for agriculture, and we employ over 2,000 people in a wide range of disciplines.

Chesterford Park Research Station is one of two research and development centres for agrochemicals, and aims to discover and then develop herbicides, fungicides and animal health products for worldwide use. Research at both sites is presently undergoing a major expansion.

To accommodate this expansion, we have created this new position for an experienced research biologist to lead a group of around 30 staff involved in crop protection research. Reporting to the

Head of Biology, you will lead and manage the Group's research projects, ensuring

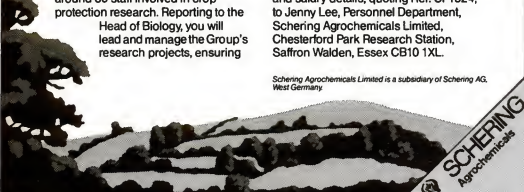
that good collaborative working relationships are established and maintained with other R&D functions. An appreciation of biochemistry would be helpful in this context.

A graduate, and ideally a PhD, you should have a good understanding of the role of agrochemicals in world agriculture. Previous involvement in field trials and experience of computer based systems for handling biological data would be advantageous.

To the person appointed, we offer a competitive salary accompanied by a range of benefits, including a company car and relocation assistance where appropriate.

The closing date for applications is 1st September 1987. Please send full career and salary details, quoting Ref: CP1524, to Jenny Lee, Personnel Department, Schering Agrochemicals Limited, Chesterford Park Research Station, Saffron Walden, Essex CB10 1XL.

Schering Agrochemicals Limited is a subsidiary of Schering AG, West Germany



PUBLIC HEALTH LABORATORY SERVICE

BOARD
PHLS Centre for Applied
Microbiology & Research

Microbial Technology Laboratory BASIC GRADE MICROBIOLOGIST

To join a group of scientists studying the microbiological degradation of recalcitrant organochlorine compounds.

You should have a good degree in microbiology, biochemistry or a related subject.

The post is funded by the Department of the Environment, and is tenable initially until July 1988.

Salary will be in the range £7452-£9996 depending on experience.

National Health Service terms and conditions.

Application forms from the Personnel Officer, PHLS CAMR, Porton Down, Salisbury, Wiltshire SP4 0JG. Please quote post No 0860.

Closing date: 24 July, 1987.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY (University of London)

Centre for Biotechnology

POSTDOCTORAL RESEARCH ASSISTANTS

Required by Prof B. S. Hartley, FRS for the following exciting projects:

1 Protein engineering of Arthrobacter glucose isomerase (supported by SERC Protein Engineering Club). Involves site-directed mutagenesis of our cloned gene based on our recent tertiary structure to improve industrial properties.

2 Genetic engineering of a novel thermophile to make ethanol at 70°C from straw hydrolysates (supported by EEC contract). Involves cloning and mutagenesis by gene-disruption to manipulate metabolic fluxes.

Salary related to both projects will be in the range £10 698-£18 218 inc. Applications to Prof B. S. Hartley FRSE, Centre for Biotechnology, Imperial College, London SW7 2AZ with cv and names of two referees by 15 August, 1987.

UNIVERSITY OF LIVERPOOL Environmental Advisory Unit

The Environmental Advisory Unit is a progressive environmental consultancy of the University of Liverpool and wishes to increase staffing with the appointment of TWO ENVIRONMENTAL FIELD OFFICERS

Applications for the two posts are invited from candidates holding a good honours degree with a broad interest in all aspects of the environment. A current driving licence, working knowledge of a second language and a willingness to learn are essential.

The posts will be offered initially for one year, further employment will be determined by the success of the individual. Initial salary will be £8185 pa.

Applications together with the names of three referees, should be received not later than 27 July, 1987, by the Registrar, The University, PO Box 147, Liverpool L69 3BX from whom further particulars may be obtained.

Quote Ref RV/550/NS.

PUBLIC HEALTH LABORATORY SERVICE BOARD

PHLS Centre for Applied
Microbiology & Research

Microbial Technology Laboratory

We are extending our activities in the development of laser and fibre optic based analytical techniques for medical biotechnology applications, in collaboration with the Royal Signal and Radar Establishment Laser Group Southampton University Fibre Optics and Addenbrookes Hospital.

APPLIED PHYSICIST— Post No. 0926.

A graduate physicist (or engineer) required with experience in applied optics, preferably with some experience in fibre optics and the ability to work within a multidisciplinary team. You will be intimately involved in leading the development and design of laser light scattering and related instrumentation systems. Interest in software development advantageous.

Salary scale: £10 632-£13 896 or £13 704-£18 948 pa dependent upon qualifications and experience.

VIROLOGIST—Post No. 0972.

Graduate required with several years experience in the preparation, identification and assay of animal viruses with an interest in developing new laser analytical techniques.

Salary scale: £7452-£9996 or £10 632-£13 896 dependent upon qualifications and experience.

Appointment is for two years in the first instance. Further information contact Dr D. J. Clarke on Tel 0980 610391, Ext 454.

Application forms from Personnel Officer, PHLS CAMR, Porton Down, Salisbury, Wiltshire SP4 0JG. Please quote post No when applying.

Closing date: 24 July, 1987.

UNIVERSITY OF GLASGOW

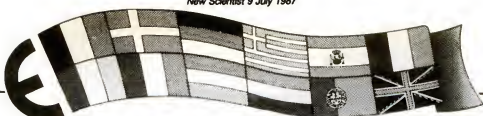
Department of Zoology
LECTURER BIOCHEMICAL
PROTOZOLOGY

Applications are invited from Biomedical Scientists in the Zoology Department and to join a group led by Dr G. H. Coombs studying the biochemistry of parasitic protozoa. It is envisaged that a successful candidate will have several years postdoctoral experience in some field of biochemical research. Previous experience with protozoa is not necessary, but the appointee will be expected to participate in the teaching of this and other aspects of biology to junior undergraduates.

This appointment will commence on 1 October, 1987 or as soon after as possible, is for three years and is funded by the Wellcome Trust. The initial salary will be up to £12 035 pa plus superannuation.

Further particulars may be obtained from the Personnel Officer, University of Glasgow, Glasgow G12 8QQ, where applications (eight copies), giving the names and addresses of three referees, should be lodged on or before 10 August, 1987.

In reply please quote Ref No 5867/1N.



THE COMMISSION OF THE EUROPEAN COMMUNITIES

is organizing two open competitions based on tests to recruit

ENGLISH TRANSLATORS and ASSISTANT TRANSLATORS

Applicants (male or female) must be nationals of one of the 12 Member States of the Community and satisfy the special conditions below

(Competition COM/LA/565)

TRANSLATORS

Nature of Duties: Translation into English of texts relating to the various sectors of Commission activity, notably: □ economics; □ science and technology.

Age limit: Born after 24 September 1951.

Qualifications: University degree.

Experience: At least two years' experience in the field of languages, economics or science and technology.

(Competition COM/LA/566)

ASSISTANT TRANSLATORS

Nature of Duties: Translation into English of texts relating to the various sectors of Commission activity.

Age limit: Born after 24 September 1954.

Qualifications: University degree (first university degree must have been obtained after 1 January 1984).

Experience: No experience required.

Knowledge of languages: Candidates must have a perfect knowledge of English and have a thorough knowledge of French or German and of one other official language of the European Communities (including French or German).

Place of Employment: Brussels, Luxembourg or any other place of Commission activity.

Applications must be made on the official application form which, together with the notice of competition, can be obtained by writing, preferably on a postcard, to: Commission of the European Communities, Recruitment Division, rue de la Loi 200, 1049 Brussels.

Please quote the number of the competition COM/LA/565 or COM/LA/566.

Closing date for submission of applications: 24 September 1987.

HICKSON TIMBER PRODUCTS LTD.

We are a major company involved in the construction industry and are market leaders in the pre-treatment, preservation and decoration of timber. We supply the timber manufacturing industry with products which include 'Tanalith', 'Vecsol', 'Decol', 'Predec' and 'Pyrolith'. We have a vacancy for a

SENIOR DEVELOPMENT CHEMIST Salary £14,000 c.

Based at Castleford, West Yorkshire, the person appointed will be responsible for the day-to-day management of the Development Section and its associated projects.

He/she will also have the authority to formulate and execute R&D projects and be expected to provide a strong chemical and product formulation expertise to the laboratories.

The successful candidate will be around 30, preferably with a PhD in the biocidal/agrochemical or related fields, with at least five years' experience in industrial research and development. The position offers scope for further advancement.

As part of the Hickson International Group, we can offer you all the benefits associated with an established successful group of companies. Relocation expenses available if required.

HICKSON

Write initially for an application form to:

Mr. R. Turner, Personnel Manager

HICKSON TIMBER PRODUCTS LIMITED

Wheldon Road, Castleford WF10 2JT. Tel: (0977) 556565

A member of the Hickson Group of Companies

ROYAL OBSERVATORY, EDINBURGH (ROE)

MILLIMETRE-WAVE ASTRONOMERS

The Royal Observatory, Edinburgh is responsible, on behalf of the Astronomical communities in the UK, Canada, Netherlands and Hawaii, for the operation of the James Clerk Maxwell Telescope (JCMT) in Hawaii. In connection with this, the ROE has two vacancies in the field of millimetre-wave astronomy.

The posts will initially be based in the JCMT section at Edinburgh but those appointed must expect to be posted to Hawaii at some stage, for a tour of duty normally lasting three years.

The successful candidates will form part of a small team of scientists and engineers dealing with the support of operations and the construction of new receivers for the JCMT.

Applicants should have a good degree in physics or astronomy, with a PhD or other evidence of experience with millimetre/submillimetre or radio astronomy, high-frequency heterodyne receivers and/or astronomical data acquisition and analysis.

Salary will be in the range £8,733pa to £11,765pa (subject to qualification and relevant experience). Limited assistance with specific relocation expenses will be available. For an application form and further details contact John Lipsett or Jocelyn Burnell at the Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ. Telephone 031-467 3321.

Closing date for the receipt of applications: 29 July 1987.

Ref: 17/20/10 C17.

An opportunity to combine UK/Eire regulatory responsibilities with a new business management role in a major international pharmaceutical company as:

Manager, Regulatory Affairs & New Projects

to c.£25,000 + car Home Counties

You are probably 30 to 40, a pharmacist or life sciences graduate, now managing a registration section in the pharmaceutical industry, working in new product development after a spell as a registration executive, or perhaps in a related role on the government side. You're looking for a way to consolidate your career as a regulatory professional, and to develop yourself as a manager through the acquisition of meaningful business responsibilities. Perhaps you're blocked in a medically-dominated department: in any event your present organisation is unlikely to offer you similar opportunities in a reasonable timescale.

In your new role, you will report to the New Business Director and manage the Regulatory Affairs Department – handling your own registrations; defining and executing appropriate regulatory strategies; ensuring compliance with best practice throughout the organisation (manufacturing, marketing, medical and QA); maintaining relationships of mutual confidence with the relevant regulatory people and colleagues in the UK, Eire and the States; having a major input into new product assessment/development in both ethical and OTC areas.

You can open up discussions on this key position by telephoning Roger Stephens/Ann Judge, or by writing now with succinct and relevant cv/presentation. Ref. 8735.

Roger Stephens & Associates

Management · Selection · Development

Chequers House, 1-3 Park Street, Old Hatfield, Hertfordshire AL9 5AT.

Telephone: (07072) 75361/2

EAST BIRMINGHAM HEALTH AUTHORITY

Regional Virus Laboratory,
East Birmingham Hospital
MEDICAL LABORATORY
SCIENTIFIC OFFICER

Salary Scale: £6368-£8986 pa.

The above post is now available in routine diagnostic virology. Work on a rotation system is in the six main sections of the department, namely isolation, rubella, serology, hepatitis (including HIV serology), electron microscopy and diarrhoea viruses. It would be an advantage if the successful applicant has previous working knowledge of diagnostic virology, but consideration will be given to candidates with basic qualifications of an HNC in Medical Microbiology or a suitable degree.

This post is funded by the World Health Organisation and is for 12 months in the first instance.

Applications, together with full cv and two referees to Mr J. R. Foster, Laboratory Manager, Regional Virus Laboratory, East Birmingham Hospital, Birmingham B9 6ST.

KENNET & AVON CANAL RESTORATION PROJECT BASED AT WOOLHAMPTON, NEAR READING, BERKSHIRE

Ecology Team Leader

£7,158 – £8,742 (depending on qualifications and experience)

An Ecology Team Leader is required to join the Kennet and Avon Canal Project in Berkshire, now in its 4th year. Applicants should have relevant qualifications and experience and a broad knowledge of fresh water and terrestrial ecology. An important part of the work will be to establish permanent monitoring sites and a practical survey strategy so that the ecological impact on the waterway can be continually assessed once it is reopened. Other work will include the organisation of a habitat survey, liaison with other groups connected with the canal and the expansion of the interpretive and educational side of the project.

Current driving licence essential.

This is a Community Programme post and to be eligible you must be unemployed, over 18 years of age and in receipt of an appropriate State Benefit.

Write for an application form to:

Chief Executive Dept., Berkshire County Council, Shire Hall, Shinfield Park, Reading RG2 9XD, or call on JOB LINE Tel: Reading 86112. Closing date: 23.7.87.

Berkshire County Council is an Equal Opportunities Employer

UNIVERSITY OF EAST ANGLIA Norwich

Research Posts in the School of Chemical Sciences

Applications are invited for the following posts:

1. Immunological Methods in Food Analysis

A research assistantship sponsored by the Ministry of Agriculture, Fisheries and Food to develop novel immunological procedures for the analysis of food contaminants. The candidate should have an interest in organic synthesis and a degree (or similar qualification) in chemistry or a related subject. The appointment will be for one year in the first instance at the appropriate point on the RA(18) scale (£8185-£11 015 p.a.). The successful candidate will be encouraged to register for a higher degree.

2. Formation and Analysis of Indoor Air Pollutants

A research studentship leading to a PhD, funded by Eastern Electricity, to investigate the formation of potential indoor air pollutants by heating elements and to develop analytical methods for their detection. Applicants should hold, or expect to obtain, a suitable degree in chemistry or a related subject and should have an interest in analytical chemistry. The appointment is for three years at a grant equivalent to an SERC studentship plus an additional allowance.

Applications with a cv and the names and addresses of two referees should be sent to Dr R. J. K. Taylor (Post 1) or Dr C. S. Creaser (Post 2) at the School of Chemical Sciences, University of East Anglia, Norwich NR4 7JT.

PUBLIC HEALTH LABORATORY SERVICE

BOARD PHLS Centre for Applied Microbiology & Research RESEARCH ASSISTANT

Two positions are available in the Molecular Genetics Laboratory for experienced technicians to work within a small research team.

You will assist in the isolation, growth and characterisation of AIDS viruses. Experience of tissue culture techniques and of working with human pathogenic material is highly desirable.

The posts which are a fixed term contract for two years, are graded at ML50 or ME7 III. The salary will be in the range £6368 - £9184 depending on age and experience. National Health Service terms and conditions will apply.

For further information and application forms contact the Personnel Officer, PHLS Centre for Applied Microbiology & Research, Porton Down, Salisbury, Wilts SP4 0JG. Tel. 0980 610391. Please quote post No 1119/1124.

Closing date: 24 July, 1987.

**UNIVERSITY OF WALES
COLLEGE OF MEDICINE
DEPARTMENT OF SURGERY**

**RESEARCH
OFFICER**

required to continue interesting work on assessing the growth-stimulating properties of fibroblasts and the effect of dietary fats on cancer growth. The successful candidate will need to be able to work independently but under scientific supervision is available within the department. The post is tenable immediately and will be for a period of one year in the first instance (subject to a probationary period) with possible renewal thereafter. Salary either on the scale for University Research and Academic Staff Grade IB (£21185-£31 015 p.a.) or 1A (£25050-£34 885 p.a.) if the appointee is post-doctoral.

Applications in the form of a cv with the names and addresses of two referees and quoting Ref No B19/2/78 should be submitted to the Registrar and Secretary (Personnel Office), University of Wales College of Medicine, Health Park, Cardiff CF4 4XN by 24 July 1987.

Despatched from Mr R. Mansel, FRCS (Tel No 0222/760644 Ref 2781)

**UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF
VETERINARY MEDICINE
RESEARCH
TECHNICIAN**

Applications are invited for the post of Research Technician (R6 grade) to join an active research group concerned with the molecular biology, immunology and pathogenesis of the herpesviruses.

The salary will be for three years and will be funded by the Equine Virology Research Foundation. The salary will be in the range £7145-£7580 according to age and experience. Applicants should have relevant qualifications in Microbiology, Biochemistry or a related subject, together with appropriate laboratory experience. Applications including a cv and the names and addresses of two referees should reach Dr H. J. Field, Department of Veterinary Medicine, Madingley Road, Cambridge CB3 0ES as soon as possible.

**UNIVERSITY OF CAMBRIDGE
Department of
Computing Science
SYSTEMS MANAGER
Ref No 5990/N
TWO GRADUATE
PROGRAMMERS
Ref No 5861/N**

Applications are invited for the post of Systems Manager and for two Graduate Programmer Posts. The applicants would manage or join a support team of five programmers in a rapidly expanding department, utilising high performance computers and bit map graphics workstations running UNIX™, Apple Macintosh computers and sophisticated local area networks. There are opportunities for research, learning and industrial collaboration within the department.

Appointments will be on Grade 2 (£11 460-£14 825) or Grade 3 (£15 415-£18 210) for the Systems Manager, and on Grade 1 (£8185-£11 015) for the Graduate Programmers. Salary will be on the scales for Administrative, Library and Computer Staff.

Further particulars may be obtained from the Academic Personnel Office, University of Cambridge, Glasgow, G12 8QQ where applications (eight copies), giving the names and addresses of three referees, should be lodged on or before 15 August 1987. In reply please quote appropriate Ref No.



Research Chemist

Howson-Algraphy, a Vickers Company, are leading manufacturers of Lithographic Printing Plates, Chemicals and Equipment.

We now have an opportunity for a Research Chemist to join the Organic Research Department, within our modern Research and Development Function.

Ideally, you will be aged 24-30, have a good honours degree in Chemistry and possibly hold a Ph.D. Knowledge or industrial experience in any of the following areas would be a distinct advantage:—light sensitive materials or lithographic compositions; surface coating formulations; polymer chemistry and synthetic organic chemistry. It is essential that you are able to demonstrate a creative and innovative approach.

The job content will be varied, with the emphasis on research, and will include responsibility for the evaluation and assessment of internally produced, and commercially available light sensitive materials, as novel and new components for lithographic plate coatings.

The Company can offer you an excellent reward package which includes competitive salary, 5 weeks annual holiday and relocation assistance where appropriate.

Please write under Private and Confidential cover, giving full details of qualifications and experience to:—
Sandra G Bateson, Staff Personnel Manager,
Vickers plc, Howson-Algraphy Group, Coal Road,
Secroft, Leeds LS14 2AL.

Howson-Algraphy

A Vickers company

£10k - £25k
Software Professionals

Our clients are leaders in software technology and are committed to providing state-of-the-art software solutions for Defence and Aerospace applications.

REAL TIME

You will need to be qualified to Degree level or higher with experience in one or more of the following:

**CORAL 66 PASCAL ADA C
FORTRAN 77
LISP PROLOG
C31 SONAR SATELLITES
EXPERT SYSTEMS
SIGNAL PROCESSING
MODELLING/SIMULATION
IMAGE PROCESSING
DATABASE DESIGN
RADAR EW**

The project environments cover:

If you have relevant experience and are seeking new challenges in a fast expanding environment with outstanding prospects, then send your CV or write/phone for an application form in complete confidence, quoting ref NS/85 to JOHN SPENCER.

Recruitment

**STW RECRUITMENT, 85 HIGH STREET
WINCHESTER, HANTS, SO23 8AP.
Tel: 0962 69478 (24 HOURS)**

**UNIVERSITY OF BRISTOL
Department of Obstetrics and Gynaecology
Reproductive Medicine Unit**

**RESEARCH ASSISTANT OR
RESEARCH TECHNICIAN**

**in
HUMAN EMBRYOLOGY
AND/OR CYTOGENETICS**

(Salary range £7274-£11 015)

Appropriately qualified graduate or technician to work in a human IVF laboratory with opportunities for wider experience and research within the University unit, which provides infertility services. The unit has extensive clinical and basic laboratory research programmes including on sperm function and reproductive endocrinology. It is closely linked with the Regional Cytogenetics Centre, where experience would also be available, and reproductive immunology laboratories.

The post will be funded from service income and would therefore be appointed for one year in the first instance but with expectation of continuing. To commence in October. Details from Mr M. G. R. Hull, Department of Obstetrics & Gynaecology (Tel 0272) 215411 Ext 293).

Applications including cv and names and addresses of two referees to The Registrar, University of Bristol, Senate House, Bristol BS8 1TH by 24 July. Interviews first week August.

**UNIVERSITY OF DURHAM
Department of Geological
Sciences
SENIOR RESEARCH
ASSISTANT**

Applications are invited for a Senior Research Assistant to work with Dr C. H. Emmeus from 1 September, 1987 until 31 March, 1988 on the preparation of the Tertiary Igneous volume of the Nature Conservancy Council's Geological Conservation Review. Preference will be given to candidates with experience of igneous petrology and who have a higher degree.

Salary £9305 pa on Grade 1A with superannuation.

Application (three copies) naming three referees should be sent (quoting Ref 01) by 28 July, 1987 to the Registrar, Science Laboratories, South Road, Durham DH1 3LE from whom further particulars may be obtained.

**UNIVERSITY
OF BIRMINGHAM
Department of Cancer Studies
RESEARCH TECHNICIAN**

required, preferably with experience in biochemistry and/or microbiology. Specific training in required techniques will be given. Ref 9498.

Salary £6314-£7448 pa. Please write or telephone for an application form to: Personnel Office, Birmingham University, P.O. Box 363, Birmingham B15 2TT. Tel 021-472 1301, Ext 2452. An equal opportunities employer.

PRODUCT DEVELOPMENT CHEMIST

Consumer Products - Surrey

Your task - to take a potential brand leader from conception to launch - in a dynamic, marketing - led environment.

Ashe Consumer Products represents the main UK operation of Akzo Consumer Products, a division of the Dutch based Akzo Group. Strong emphasis on Marketing and R & D has produced a wide variety of high profile brands - Amplex, Maws, Vapona, Vitapointe and Sherley's.

A highly dynamic and fast moving market place requires that R & D work closely with the commercial functions of Marketing and Sales to respond quickly to the needs of the Consumer. Due to internal promotion, we are looking for a Product Development Chemist to join our highly skilled R & D team based at Leatherhead, in Surrey.

We anticipate this challenging role will appeal to someone aged 25-30, with a BSc in Chemistry or similar qualification. Ideally you should have at least 4-5 years experience of new product development in the toiletries, pharmaceutical or food industry, and have the ability to communicate effectively at all levels of the organisation. Regular liaison with our manufacturing site in the North West of England will be an integral part of the job.

If you are appropriately qualified and have the necessary personality and experience to communicate clearly, work under pressure and deliver results, then we can offer you a highly competitive salary and benefits package, and structured career development opportunities.

Interested applicants should please write to:-
Carol Clark, Personnel Officer,
Ashe Consumer Products Limited, Ashtree Works,
49 Kingston Road, Leatherhead, Surrey KT22 7JZ
telephone: 0372 376151 for an application form.



ASHE CONSUMER PRODUCTS LTD.



SOUTH GLAMORGAN HEALTH AUTHORITY

National Blood Transfusion Service (Wales)

JUNIOR 'B' MEDICAL LABORATORY SCIENTIFIC OFFICER

£4354 (at age 18)-£5588 pa

The successful applicant, who will have a suitable science degree, will have the opportunity of gaining wide experience in all aspects of laboratory work associated with this busy Regional Transfusion Centre. Training will be given to prepare for state registration and encouragement will be given to gain higher qualifications, and pursue a career in Transfusion Science.

Application forms and job description available on receipt of fee from: Personnel Department, National Blood Transfusion Service, Rhydylafar, Cardiff. Closing date: 29 July, 1987.

UNIVERSITY OF LIVERPOOL

Department of Neurological Sciences

Applications are invited for the post of SENIOR RESEARCH ASSISTANT

in the Department of Neurological Sciences. The successful candidate will be required to record pain-evoked potentials.

The post is tenable for two years from 1 August, 1987 at an initial salary within the range £9305-£13,675 pa.

Applications, together with the names of three referees, should be received not later than 24 July, 1987 by The Registrar, The University, PO Box 147, Liverpool L69 3BX, from whom further particulars may be obtained.

Quote Ref RV/552/NS.

TEMPORARY LECTURER II/ SENIOR LECTURER IN PHYSIOLOGY

Applications are invited for the above post in the Department of Biological Sciences, for one year from September 1987.

The successful applicant will teach physiology to undergraduates and make a contribution to the teaching of post-graduates on the MSc (Neurophysiological Basis of Behaviour) course. Research opportunities are available.

Ideally candidates will have a post-graduate qualification, be qualified in Mammalian Physiology and have a strong interest in Neurophysiology.

Salary scale: LII-£9810 to £14 871 pa; SL-£13 830 to £16 035 pa (bar) £17 088 pa; Salaries include London Weighting.

For further details and an application form please write to a post-card to the Deputy Personnel Officer (Recruitment), City of London Polytechnic, 117-119 Houndsditch, London EC3A 7BU quoting reference number 87/92.

The Polytechnic is an equal opportunities employer

CityPoly

We are positively committed to a policy of equal opportunity for all. We look forward to receiving suitable applications from all sections of the community which will be considered on merit, regardless of sex, age, race, ethnic origin, marital status, responsibility for dependants, sexual orientation or disability.

Senior Development Scientist Polymer/Materials Science

Our client, BIOCMPATIBLES LTD., is a newly formed biotechnology company based in Uxbridge, Middx., and is involved in the commercialisation of polymers designed to mimic the characteristics of a human cell membrane.

The company urgently seek to appoint an experienced Polymer/Materials Scientist to pioneer the development of new biocompatible polymers for such diverse applications as surgical implants, extra corporeal blood contact devices and tissue culture ware.

Applicants, aged 27-35, should be qualified to MSc/PhD level and have current working knowledge of polymer/materials design. Preference will be given to candidates working within the healthcare or a related industry.

An attractive salary package is on offer and will be individually negotiated dependent upon age and experience.

To apply, call Celia Randall on

01-222 6334 immediately

**Ross Warren
Recruitment**

UNIVERSITY OF WARWICK
Department of Biological Sciences

RESEARCH TECHNICIANS (4 posts)

In the RICH Research Group to work on the modification of toxin genes using cloning techniques, DNA sequencing, expression, site directed mutagenesis and the biological evaluation of recombinant proteins.

The posts are SERC funded and available for up to three years.

Please Quote Ref 47/T/86/F.

RESEARCH TECHNICIANS (3 posts)

In the PLANT BIOCHEMISTRY Research Group to work on the expression of genes encoding glutamine synthetase or the targeting of foreign proteins to higher plants, or the molecular biology of protein transport into chloroplasts.

The posts are Industrially funded and available for two years.

Please Quote Ref 47/2T/86/F.

RESEARCH TECHNICIANS (2 posts)

In the MICROBIOLOGY Research Group to work either on fermentation/microbial physiology involving gas analysis by mass spectrometry and gas chromatography or the purification and characterisation of the enzyme Methane Monooxygenase from batch and continuous cultures using HPLC, GC enzyme assays, etc.

The posts are Industrially funded and available for 18 months.

Please Quote Ref 47/3T/86/F.

RESEARCH TECHNICIAN

In the MICROBIOLOGY Research Group to work on the production of hydroxylated aromatic compounds by microorganisms. The work will involve the maintenance of bacterial cultures and the assay of culture products using HPLC and spectrophotometric methods, followed by the extraction and purification of organic products.

The post is SERC funded and available for three years.

Please Quote Ref 47/4T/86/F.

Applications are invited for the above posts from graduates or others with qualifications and experience in biochemistry, microbiology, molecular biology or genetics.

Salary for all posts will be on Technician Grade 3 scale: £6314-£7448 pa.

Application forms from the Personnel Office, University of Warwick, Coventry CV4 7AL (0203 523685) quoting the appropriate Ref No. Closing date 23 July, 1987.

AN EQUAL OPPORTUNITIES EMPLOYER

INSTITUTE OF
HORTICULTURAL RESEARCH
LITTLEHAMPTON
Entomology and Insect Pathology
Department

Short-term post (18 months)

A SCIENTIFIC OFFICER

is required for an appointment funded by AGC to investigate the use of insect-parens nematodes for the biological control of cabbage root fly in field grown brassica crops, initially at IHR, Littlehampton, later transferring to IHR, Wellesbourne.

Qualifications: Good honours degree in Entomology, Applied Biology or related subject.

Salary: £6973-£9585. Non-contributory superannuation.

Apply for further details, quoting Ref 9/L to Personnel Officer, Institute of Horticultural Research, Bradbourne House, East Malling, Maidstone, Kent ME18 6JL.

The Institute of Horticultural Research is an equal opportunities employer.

BARNETT & FOSTER LIMITED RESEARCH SCIENTIST

This is a unique opportunity to join a research team applying the latest biotechnology to the production of natural flavours.

Barnett & Foster Limited are a leading British Company specialising in the creation and manufacture of flavours, fruit juices and concentrates for the food and drink industries with increasing sales throughout the UK and worldwide.

Personality must be such as will enable the successful applicant to integrate within a research team working on natural flavour preparations. We would also look for evidence of creativity, communication skills and a grasp of the disciplines required for research and development work.

Applicants must hold either a PhD or good degree in biochemistry or a related subject and ideally have experience of modern analytical techniques applicable to natural flavour research.

If you would like to join an expanding and successful company, where there is an opportunity for career development, please write, giving details of experience and qualifications to: Miss A. Gill, Personnel Officer, Barnett & Foster Limited, Denington Estate, Wellingborough, Northants NN8 2QJ.

Assistant Technologist

(CHOCOLATE AND BAKERY RESEARCH)

Some of the best loved names in British biscuits and confectionery products are manufactured by United Biscuits - McVities, Crawfords, Terry's of York to name a few.

Our Research and Development team is of vital importance in maintaining our high standards of product quality and developing new ideas and we are looking for a creative young scientist to join our team. You will initially be based at Maidenhead and move to High Wycombe early next year.

As an Assistant Technologist, you will help develop new processes and techniques and carry out experimental work to solve problems particularly associated with the manufacture of chocolate, biscuits and other related products. This will involve occasional travel to sites in the U.K.

You should be a graduate in science or food technology and have experience in the food industry, preferably working with chocolate. We can offer enthusiastic and talented people a good career with a successful company. Interested?

For an application form and job description please telephone or write quoting reference AD to Miss S. Ainsworth, Personnel Officer (HQ), United Biscuits (UK) Limited, Grant House, PO Box 40, Syon Lane, Isleworth, Middlesex TW7 5NN. Tel: 01-560 3131 Ext 4506.



United Biscuits

MCVITIES • CRAWFORDS • KP FOODS •
WIMPY • UB FROZEN FOODS • TERRY'S OF YORK •
PIZZALAND • KEEBLER (USA) •

PUBLIC HEALTH LABORATORY SERVICE BOARD

Public Health Laboratory,
Dulwich

MISO/JUNIOR 'B' IN
VIROLOGY

This two year post would suit either a person who wishes to study for the Fellowship examination in Virology or a new graduate wishing to become State Registered since a full range of viral diagnostic investigations including electron microscopy are performed in this busy laboratory.

The laboratory provides a Public Health Laboratory Service for South East London and a Diagnostic Service for Camberwell Health Authority and six other laboratories in the SE Thames Region.

For information and arrangements to visit the laboratory contact Mr P. Bracken, Chief Medical Laboratory Scientific Officer on Tel 01-693 3377, Ext 3046.

Closing date 30 July, 1987.



THE WILDFOWL TRUST

The Wildfowl Trust has, since it was founded in 1946 by Sir Peter Scott, become a powerful force in the conservation of wildfowl and their wetland habitats. It has eight operational centres in Britain and is also involved in wide-ranging programmes of research and education.

The Trust has decided to create the new post of Director-General to head its operations. The person appointed should already have an outstanding record in the field of nature conservation, be involved in, or at least deeply interested in, research and/or education. Management experience at senior level will be an added advantage.

The Director-General will be responsible for the direction and management of all the Trust's activities and for the selection, motivation and rewards of its staff. The person appointed would recommend and execute the strategy of the Trust and also represent it on matters of research, conservation and education in the broader public domain.

It would be desirable for the Director-General to be able to serve in that position for at least ten years.

A salary commensurate with the importance of the position will be negotiated.

Applications together with a detailed cv should be forwarded in the first instance to D. J. Billingham, Director of Finance and Administration, The Wildfowl Trust, Slimbridge, Glos GL2 7BT.

June 1987.

R Research Bioanalyst

Upjohn Limited, the UK subsidiary of one of the world's largest pharmaceutical organisations, is involved in the development, manufacture and marketing of a wide range of ethical products. We are a highly progressive organisation and we have a particularly strong commitment to research. Following a recent promotion, we now have an opportunity for a Bioanalyst to join our Research Centre in Crawley.

In this responsible position (which includes supervision and training of junior staff), you will be making a significant contribution to our drug development programme. You will work with some of the most advanced equipment, concentrating on the development, validation and application of new methodologies, based on high pressure liquid chromatography, for the analysis of drugs and their metabolites.

You will be from either an academic or an industrial background, and have several years' experience of undertaking research into HPLC methods of bioanalysis. This experience should be supported by a BSc, and possibly a PhD, in an appropriate subject. Ideally, you will also be familiar with micro-processor equipment, LIMS and GLP, and you should certainly be able to demonstrate the ability to adopt innovative approaches to problem-solving.

In addition to a starting salary of £12,500 to £15,500 (depending on qualifications and experience) and an attractive package of benefits, we can offer the advantages of working for an expanding department, the challenges of a stimulating work programme, and excellent long-term career prospects.

To apply, please send a full CV to Pamela Gelder, Personnel Co-ordinator, Upjohn Limited, Fleming Way, Crawley, West Sussex RH10 2NJ. For further details, telephone her on 0293-589227.

Upjohn

THE UNIVERSITY OF NEW SOUTH WALES

Sydney, Australia

Associate Professor of Drug and Alcohol studies to be

DEPUTY DIRECTOR

National Drug and Alcohol Research Centre

Applications are invited for appointment to the position of Associate Prof. of Drug and Alcohol Studies to be Deputy Director of the National Drug and Alcohol Research Centre. The Centre has been established within the University on the basis of funding provided by the Commonwealth Government through the State Department of Health. Its aim is to extend the knowledge base required for effective treatment and rehabilitation of individuals with alcohol and drug related problems. A second national Centre has also been established in Perth, Western Australia, which will undertake research into the prevention of drug abuse.

The Centre will be multi-disciplinary and co-operate with medical, psychology and social science schools at the University and with other bodies and individuals in Australia.

Applicants should possess high academic qualifications, have a well established record of research in this field and have the capacity to manage a research program.

The appointment will be for five years with a possibility of renewal.

Enquiries regarding the position may be directed to Prof. I. W. Webster, Head of the School of Community Medicine and Chairman of the Steering Committee of the Centre, University of New South Wales, PO Box 1, Kensington, NSW 2033, Australia. Salary: \$A49 790 pa.

Subject to consent by the University, professors may undertake a limited amount of higher consultative work.

For full information about conditions of appointment and method of application write to the Secretary General, Association of Commonwealth Universities, 36 Gordon Square, London WC1H 0PF.

Applications close: 31 August, 1987.

Equality of employment opportunity is University policy.

THE LONDON HOSPITAL

MEDICAL COLLEGE

(University of London)

LABORATORY SCIENTIFIC

OFFICER

required for the Bone and Joint Research Unit. The appointee will work as an assistant on a project studying the use of various macromolecules as markers of joint inflammation. New graduates in biochemistry will be considered as well as applicants with previous laboratory experience. The post is for one year initially. Salary in the range £6368-£7264 (according to age) plus £1133 London Weighting pa. Applications to the Assistant Secretary, The London Hospital Medical College, Turner Street, London E1 2AD within two weeks of this advertisement. Informal enquiries should be made to Dr P. W. Thompson. Tel 01-777 7764.



NATIONAL MICROELECTRONICS RESEARCH CENTRE

NATIONAL MICROELECTRONICS RESEARCH CENTRE,
UNIVERSITY COLLEGE,
LEE MALTINGS, PROSPECT ROW,
CORK, IRELAND

The National Microelectronics Research Centre was established at University College, Cork in 1982. Its principle aims are to participate in applied research and development in the design and fabrication of integrated circuits. Over half of the complement of 80 staff and post-graduate students are supported by R&D contracts, carried out in the Centre, funded by indigenous and overseas companies and agencies. The topics of investigation are spread over four main technical areas, namely Silicon IC design and fabrication, Gallium Arsenide device and IC technology, Computer Aided Design and IC interconnection and Packaging technology.

Among the Centre's facilities are a fully equipped laboratory for the fabrication of Silicon ICs which is currently running a polysilicon gate CMOS process, extensive CAD facilities, a complete mask making service, laboratories for the fabrication of thick film/hybrid circuits and GaAs devices and circuits as well as comprehensive test and diagnostic facilities.

SENIOR RESEARCH SCIENTIST

The NMRC has a vacancy for a senior person, preferably qualified to doctoral level, who has experience in one or more of the Silicon IC topics of process development, device physics and fabrication technology.

The responsibilities would include:

- Pursuing state of the art research in silicon technology
- Supervising on going work on EEC and industrial funded R&D projects
- Lecturing in the area of silicon technology

The position will be attractive to a highly motivated individual interested in developing their technical expertise through working in a well equipped modern laboratory with a highly skilled staff.

Applicants should forward a detailed cv as soon as possible to the above address for the attention of Mr M. O'Sullivan, Administration Manager, for further details telephone 021 276871 Ext 2644/2256.

DEVELOPMENT CHEMIST

Naffloc Limited is an ICI subsidiary company and a leading supplier of speciality effect chemicals to industry.

Expansion of the Oil Section of our laboratory has created a vacancy for a development chemist. The successful candidate will undertake applied research and development of speciality effect chemicals for the oil production and refining industries. The job will be laboratory based but will involve site work on offshore oil production platforms and at oil refineries.

We are seeking a good honours graduate who can generate original ideas and is a good practical experimentalist.

The starting salary will be in excess of £9500. Fringe benefits are those typical of a successful and progressive company.

Please write for an application form to:



PERSONNEL DEPARTMENT

Naffloc Limited
PO Box 11
Northwich
Cheshire CW8 4DX

Closing date for applications: 3 July, 1987.

AUSTRALIA

CSIRO

RESEARCH SCIENTIST

A\$28 475—A\$41 861

DIVISION OF ATMOSPHERIC RESEARCH
ASPENDALE VIC 3195

FIELD: Climate Dynamics.

GENERAL: The Division of Atmospheric Research maintains broadly-based research programs in climate dynamics, global and local air pollution studies, satellite and remote sensing, and atmospheric physics and chemistry.

The Division's Large Scale Dynamics program is concerned with regional and global scale climate including the mechanisms underlying climate variability and change, and the impact of climate change, including studies of the GREENHOUSE effect and the predictability of Australian rainfall variations. The Division has a suite of atmospheric models available and access to CSIRO's CYBER 205 computer.

DUTIES: To undertake research in theoretical climate dynamics initially with special relevance to equatorial atmosphere-ocean interactions and the El Niño-Southern Oscillation phenomenon.

QUALIFICATIONS: A PhD or equivalent qualification in the physical sciences with demonstrated ability. Preference will be given to an applicant having experience with coupled atmosphere-ocean models.

TENURE: Indefinite with Australian Government superannuation benefits.

MORE INFORMATION: Prospective applicants are invited to telephone Dr Barry Pittcock on (03) 586-7666 for further information. Dr Pittcock can also provide a copy of the detailed job description and selection criteria.

APPLICATIONS: Stating relevant personal particulars, including details of qualifications and experience, the names of at least two professional referees and quoting reference No A1148, should be directed to:

The Chief
CSIRO Division of Atmospheric Research
Private Bag No 1
MORDIALLOC VIC 3195 AUSTRALIA
By 7 August, 1987.

CSIRO IS AN EQUAL OPPORTUNITY EMPLOYER

FACULTY OF SCIENCE AND TECHNOLOGY

TECHNICIAN

BIOTECHNOLOGY PILOT PLANT

£9813 to £11 529

Applications are invited for the above position which will be vacant from September 1987. The successful appointee would be responsible for the day-to-day operation of a major new biotechnology processing facility, commissioned earlier this year. This plant provides the main pilot-scale capability within the London Centre for Biotechnology. It is to be used for teaching, training and research and for small-scale manufacturing of bioproducts. It includes fermenters as well as a wide range of up and downstream processing unit operations.

Candidates should preferably have significant experience of the installation, operation or maintenance of pilot or semi-technical scale bioprocesses. It is likely that the successful applicant will be a graduate or hold an HNC/D in an appropriate engineering or technology discipline, together with some line management experience.

Application forms and further details are available from the Personnel Department, South Bank Polytechnic, Borough Road, London SE1 0AA. Tel 01-928 3512 (answering service 9.00 am to 8.00 pm).

Please quote Ref: ST63.

Closing date for applications: 24 July, 1987.

An Equal Opportunities Employer.

**South Bank
Polytechnic**

Teaching for tomorrow
in the heart of London

SCHERING

Technical Officer

Support Services – Stapleford

Schering AG, West Germany, is a major force in the chemical industry worldwide. Within the UK Schering's interests include pharmaceuticals, industrial chemicals, electroplating and crop protection, and the company employs over 2,000 people in a wide range of disciplines.

In the UK crop protection market we are known as Schering Agriculture. We have our headquarters in Nottingham, our own sales, marketing, technical and distribution facilities, and we have a reputation for providing the farming community with service and products of the highest quality.

We are looking for a Technical Officer to join our Headquarters based, Technical Servicing Team, to undertake assigned projects involved with the establishment and maintenance of Departmental Systems, aimed at

streamlining and improving all aspects of technical support.

There is involvement in activities ranging from our internal vewdata network, to the progression of tank-nix proposals and some technical copywriting.

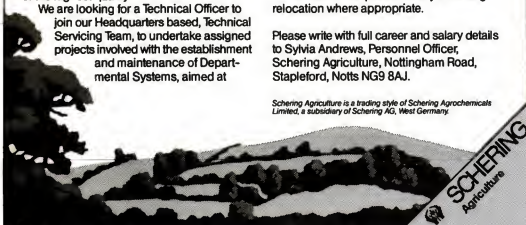
We expect you to hold a degree or equivalent in agricultural or biological science, and to have some knowledge of the use of pesticides in UK agriculture.

You will need good interpersonal skills, capability in written communications and a flair for technical administrative systems.

We offer a competitive salary including relocation where appropriate.

Please write with full career and salary details to Sylvia Andrews, Personnel Officer, Schering Agriculture, Nottingham Road, Stapleford, Notts NG9 8AJ.

Schering Agriculture is a trading style of Schering Agrochemicals Limited, a subsidiary of Schering AG, West Germany



UNIVERSITY OF STIRLING
Microprocessor Group
Computer Unit

Microprocessor Systems Engineer

Salary £8185-£12 605

The Microprocessor Group provides technical support for Microprocessor and Microcomputer applications throughout the university, and also undertakes industrial consultancy work.

Applications are invited for the post of Systems Engineer in the group. Applicants should have a degree, with experience of Microprocessor Systems Design, and an interest in Microprocessor-Controlled Instruments and Industrial Applications.

There are no application forms. Written applications with full cv including the names and address of three referees, should be sent to the University Secretary, University of Stirling, Stirling FK9 4LA, by 20 July, 1987. From whom further particulars are available. Telephone (0786) 73171, Ext. 2314.

UNIVERSITY COLLEGE LONDON
Department of Geography

POSTGRADUATE RESEARCH ASSISTANT IN ENVIRONMENTAL CHEMISTRY

Applications are invited for a Research Assistant (Range 1B) to work with Dr R. W. Battarbee in the Palaeoecology Research Unit on the morphology and chemistry of 'peat' and fly-ash particles found in lake sediments. Candidates should hold or expect to hold a good degree in Chemistry, Environmental Science, Physical Geography or a related subject. The appointee will be encouraged to register for a higher degree. The project is funded by the Central Electricity Generating Board for a period of two years beginning on 1 October, 1987. Initial salary will be £6078 pa. Enquiries and applications should be addressed to Dr R. W. Battarbee, Department of Geography, University College London, 26 Bedford Way, London WC1H 0AP.

ANALYTICAL CHEMIST

A vacancy exists at our Central Chemical Laboratory in South London for an analytical chemist. The work is mainly concerned with chemical analysis of a range of building and associated materials. Applicants should be qualified in chemistry to at least HNC or equivalent with a minimum of five years relevant experience.

The salary will be related to qualifications and experience. This is a staff appointment with appropriate benefits, including season ticket loan, luncheon vouchers and initially four weeks holiday a year.

Send brief details of age, qualifications, experience and salary required to:

The Personnel Manager Messrs. Sandberg 40 Grosvenor Gardens LONDON SW1W 0LB

SANDBERG

Trainee Analyst (Management Systems)

Salary: £7395 to £8475

Based in Reading

The Information Maintenance Group of Management Systems is responsible for ensuring the authenticity and completeness of the Authority's corporate data. Initially you will be working on the collation of asset and operation data, at present contained in a variety of computer systems but eventually most data will be moved to a new IBM mainframe. Part of the duties include routine typing and filing.

You should normally possess one 'A' level in a technical discipline, and an ability to type. Previous experience with computer systems would be an advantage, but training will be provided if necessary.

We offer a 35 hour week (flexi-time), a minimum of 22 days holiday and a pension scheme with interchange facilities.

Application forms can be obtained from the Personnel Director, Room 312, Kings Meadow House, c/o Nugent House, Vastern Road, Reading RG1 8DB. Telephone: Darron Easton, Reading 593822.

Please quote Ref: MS422/4663.

Closing date: 27 July, 1987.



RUNNING WATER FOR YOU

FOOD SCIENTIST/ TECHNOLOGIST-FISH

Marine Harvest is the leading Company in the Scottish salmon farming industry. We also have a leading role within Unilever Companies and Research Departments for developing aquaculture technology on a world wide basis. Our development department at Lochailort, 25 miles west of Fort William plays a major part in this. The Development Manager and his team of four assistant scientists are currently involved in investigations in the areas of stock improvement, feeds, husbandry, harvesting and handling.

We are now seeking to strengthen this team by the appointment of a scientist who can apply biochemical/physiological skills to understanding how nutrition, genetics, husbandry and post harvest handling affect carcass quality and fish health. The person appointed will become the focus for all work which affects the carcass quality of the fish.

Much of this work will be the design and implementation of investigational projects. These will require liaison with other groups, both inside and outside the Company, whose activities depend on or affect quality i.e. Sales, product development, farming, feeds and processing. The development of objective quality specifications will be a key initial responsibility of the job.

Educated to at least first degree level in a relevant discipline, candidates should also have a proven research record of relevance to animal carcass quality.

Please ring 031-336 1777 for an application form or write with full details to: The Personnel Manager.

MARINE HARVEST



Marine Harvest Limited
Craigcrook Castle
Craigcrook Road
Edinburgh. EH4 3TU

UNIVERSITY OF ABERDEEN Department of Bio-Medical Physics and Bio-Engineering RESEARCH ASSISTANT

required immediately for this three-year post funded by the Arthritis and Rheumatism Council.

The project will involve a study of the effects of Therapeutic ultrasound on cells, tissues and animals in order to clarify the nature of the sound tissue interaction and define the threshold of safety. Applicants should be recent graduates (at least a good second class honours degree) with experience in physics and electronics or computer science. Salary £185-£2805 pa on the BS scale for Research and Analogous Staff.

Further particulars and application forms from The Personnel Office, The University, Regent Walk, Aberdeen AB9 1FX (0224 480241, Ext 6351/4), to whom applications (two copies) should be returned by 3 July, 1987. (Ref WJ/062)

LONDON BOROUGH OF NEWHAM

St John's Catholic School
Green Street, London E13 9AX
Head Teacher Mr E. J. M. Lawton
Number on roll 500

TEACHER IN CHARGE OF
PHYSICS AND INFORMATION
TECHNOLOGY Scale 3

Required September, 1987 or as soon as possible. To teach Physics throughout the school. GCSE and 'A' level work included. London Allowance £1215.

Application forms/further particulars (see please) available from The Head Teacher to whom completed forms should be returned by Thursday, 23 July, 1987. Director of Education, Education Offices, 379/383 High Street, Stratford E15 1mm. An Equal Opportunities Authority.

Product Registration

An International Opportunity Pharmaceuticals West Germany

Operating on a world wide basis, Boehringer Ingelheim is a market leading, research-based ethical pharmaceutical company. Our success is built on the quality of our products and the calibre of personnel. Product registration plays a key role in ensuring our success.

Based at our Head Office in Ingelheim, West Germany, we seek a top calibre Product Registration Officer to join our highly professional team.

Your main responsibilities will be to co-ordinate international registration activities on medical products, naturally involving liaison with senior colleagues from research, medical and marketing departments. Although based in Germany, the centre of our operations, you will also be expected to travel overseas: a truly international role.

This challenging opportunity requires meticulous standards of analysis and attention to detail. So our Product Registration Officer is a committed pharmacist or natural scientist, with a genuine experience of product registration gained on an international basis or in a major developed country. Above all, you must be able to evaluate and summarise scientific reports in a way which pulls the essential facts from a large volume of data. Fluency in English is essential and a command of German would be a distinct advantage.

To match the demands of this job we offer a highly attractive salary package, first-class terms and conditions of service, together with relocation costs.

Initial interviews will be held in the UK in July. Interested? Contact the Personnel Department on 0344 424600 extn 232. Alternatively send full career details to: Director of Personnel, Boehringer Ingelheim Limited, Elsiefield Avenue, Bracknell, Berkshire RG12 4YS.



Boehringer Ingelheim

UNIVERSITY OF DUNDEE Department of Biochemistry

TECHNICIAN

required for a CRC-funded study of Colgi apparatus in animal cells. Project involves immunocytochemical and morphometric analyses at the electron microscope level. Preference will be given to candidates with prior experience of electron microscopical techniques though the position could also suit a keen university graduate. The appointment is available immediately until 31 October 1988 with the possibility of extension.

Salary is negotiable within the Grade 3 scale £514-£7446 pa. Applications should include a curriculum vitae along with the names, addresses, and telephone numbers of two referees. They should be sent as soon as possible to the Personnel Officer, University of Dundee, Dundee DD1 4HN, quoting ref. no. EST/112/87/N.

Informal enquiries should be addressed to Dr J. Lucoca, Tel 0382 23181 Ext. 4744.

Graduate Scientist

The UK based International Development Laboratories of E. R. Squibb & Sons, a major multinational Pharmaceutical company, are responsible for developing new products in support of Squibb's international operations.

We now have a vacancy for a young scientist to work in pharmaceutical analysis. The successful applicant will work in the Stability Studies Group which is responsible for generating data on the stability of new pharmaceutical products. In addition to carrying out analyses (mainly by HPLC), you will be required to maintain, and develop the use of, automated analytical equipment, in particular a Zymate laboratory robotic system.

Candidates should hold an Honours degree in Chemistry or related subject. A few years relevant experience gained in either industry or through further education, would be an advantage.

In addition to a competitive starting salary, we also offer large Company benefits including a non-contributory Pension and Life Assurance Scheme and free BUPA membership. Where appropriate relocation assistance will be offered.

Based near the M53 our purpose-built laboratories and pilot plant has easy access to Wales, Chester, Liverpool and the Lake District. The coast and attractive Cheshire countryside are within easy reach of the Wirral and social, cultural and shopping amenities are excellent.

Please write giving full details of qualifications and experience to date to: Miss Gwynne Harrap, E. R. Squibb & Sons Ltd, Reads Lane, Moreton, Wirral, Merseyside L46 1QW.



TECHNICAL INFORMATION SCIENTIST

A wide ranging challenge for a young information professional

With sales approaching £700 million per annum, Express Foods Group is one of Britain's leading food producers. As our business becomes increasingly diverse and sophisticated in terms of products manufactured and processes applied, we are constantly seeking professional specialist personnel.

As part of the Research and Development team, you will be responsible for the provision of a comprehensive technical information service. You will enjoy a very wide brief dealing with everything from patent information to the management of the company's bibliographic database and technical library. Candidates should hold a degree in food science or a science discipline and

preferably an information science qualification. An outgoing personality, good organisational ability and excellent oral and written communication skills are essential. Familiarity with online information retrieval and experience of database software (preferably MicroCAIRS) would be an advantage.

This interesting role offers good career prospects, not only within the Express Foods Group but also in our parent company, one of the most active and extensive groups in the United Kingdom. As a result, a full range of company benefits accompanies the attractive salary offered for this position. *Established 1980* Please write with career details to: Denise Blunn, Personnel and Training Officer, Express Foods Group Limited, Victoria Road, South Ruislip, Middlesex HA4 0HF.



THE UNIVERSITY OF ADELAIDE

Invites applications from both women and men for the following position:

RESEARCH ASSOCIATE

(Ref 9010) at the Waite Agricultural Research Institute to commence in early 1988. The Associationship may be held in any department of the Waite Agricultural Research Institute, namely the Departments of Agricultural Biochemistry, Agronomy, Animal Sciences, Entomology, Plant Pathology, Plant Physiology, Soil Science and the Biometry Section.

Applicants should have gained their PhD qualification elsewhere than at the University of Adelaide.

The Associationship will be tenable for two years from the date of commencement and will not be renewable; no age limit governing eligibility has been specified but normally a 10 year limit since the award of the most recent higher degree qualification will apply.

Travel Provision: The University will provide, for a person taking up appointment from outside South Australia, an air fare to Adelaide by the shortest practicable route. There is no provision for transfer of personal effects.

Information about the general conditions of appointment may be obtained from the Senior Assistant Registrar (Personnel) at the University, or the Secretary General, Association of Commonwealth Universities (Appts), 36 Gordon Square, London WC1H 0PF.

Salary pa: A\$24 535 x 5—A\$28 029

Applications must be made on the prescribed form obtainable, together with a leaflet outlining conditions of appointment, from the Senior Assistant Registrar (Personnel) of the University of Adelaide with whom applications must be lodged, GPO Box 408, Adelaide, South Australia, 5001. Telex UNIVAD AA 89141 not later than 28 August, 1987.

The University reserves the right to make enquiries of any person regarding any candidate's suitability for appointment, not to make an appointment or to appoint by invitation.

The University of Adelaide is an equal opportunity employer.

NOTTINGHAM HEALTH AUTHORITY

City Hospital

RESEARCH TECHNICIAN

FULL-TIME

Graduate immediately required to join a team studying the Adult Respiratory Distress Syndrome within the Respiratory Medicine Unit. The position is funded for 15 months and the initial salary will be on an appropriate point of the MISO scale.

Application forms and job descriptions from the Personnel Department, Unit HQ, Sherwood Wing, City Hospital, Hucknall Road, Nottingham NG5 1PB. Tel: 625459 (24 hour answering service). Closing date: 24 July, 1987.

EXPRESS FOODS GROUP

Project Manager

Pharmaceuticals

As leaders in the research and development of ethical pharmaceuticals, Smith Kline & French have a reputation for excellence, innovation and responsibility within the industry. Housed in a country estate of 39 acres in Hertfordshire, we are seeking an additional man or woman with strong scientific and organisational skills and an influential personality to join the expanding UK section of our worldwide Project Management Team.

The successful candidate will have responsibility for the co-ordination and progress of work on multi-disciplinary development projects, so close collaboration with a wide range of pre-clinical and clinical scientists will be essential. In addition to these operational aspects of the job, Project Managers are expected to develop a broad view of the portfolio and, with the aid of appropriate quantitative techniques, to recommend action in support of the strategic goals of R&D.

We require a person with a PhD, probably in a biomedical science, considerable initiative and industrial experience which has resulted in a good general understanding of many aspects of pharmaceutical R&D. For that person, opportunities for career progression within Project Management, or related functions in SK&F worldwide will be attractive.

Applicants for Project Management positions advertised previously will be re-considered for this post.

We pay excellent salaries and offer a good range of benefits.

Please send a detailed CV, quoting reference number NS/PJB/98 to Penelope Bucknell, Personnel Manager, Smith Kline & French Research Limited, The Frythe, Welwyn, Herts, AL6 9AR.

SK&F

KING'S COLLEGE LONDON (KQC)

(University of London)
Department of Anatomy and Human Biology
POSTDOCTORAL RESEARCH ASSISTANT
Applications are invited for a three year MRC-funded Post-doctoral Research Assistantship to work with Dr L. R. Fraser on a study of adenosine and cAMP regulation of mammalian sperm fertilizing ability. A variety of biochemical techniques will be used to investigate mechanisms controlling cAMP production and utilisation during mouse sperm capacitation in vitro. Preference will be given to applicants with experience in appropriate enzyme assay techniques and electrophoresis; experience in sperm culture is not required. Salary will be within the range £9305-£10 440 plus £1393 London Allowance, on the IA scale. Further particulars and application forms may be obtained from Mr G. A. Guthbert, Personnel Office, King's College London (KQC), Strand London WC2R 2LS. Closing date 10 August, 1987.

BATH DISTRICT HEALTH AUTHORITY

BASIC GRADE PHYSICIST
Required for Department which provides a wide range of Physics Service to four Health Districts (Bath, Salisbury, Swindon, West Dorset) based in Bath. The appointee will be involved in radiotherapy, laser and UV therapy and in the application of other non-ionising radiation in medicine. An interest in computing and instrumentation is desirable. Opportunities to obtain a higher degree and further training and time allowed for development of research activities in one of the research interests of the Department. Good honours degree required in Physics or appropriate subject. £6660-£9996 pa (under review) with initial placement depending on qualifications and experience. The post is funded for three years in the first instance with continuing funding probable. SAE for application form and job description to Val Russell, Assistant Personnel Manager, Royal United Hospital, Combe Park, Bath. Closing date: 31 July, 1987.

UNIVERSITY COLLEGE LONDON

Department of Pharmacology
RESEARCH TECHNICIAN
required for two years initially. In our MRC neurotransmitter receptor research group to culture a variety of mammalian and peripheral neurons for electrophysiological research. Work comprises the development of new culture techniques, cell typing via labelled monoclonal antibody binding as well as assistance in the running of a growing research group. Independent electrophysiological research is also a possibility. Applicants should be interested in, or experienced in tissue culture techniques and have some general laboratory experience. Salary will be in the range £7778-£10 561 including London weighting (scale dependent on age and experience). Application forms available from the Personnel Officer (Technical Staff E3), University College London, Gower Street, London WC1E 6BT. Further particulars may be obtained from Dr S. G. Cull-Candy, Department of Pharmacology, University College London.

ROYAL FREE HOSPITAL

Department of Medical Physics and Computing
MEDICAL PHYSICS TECHNICIAN
Grade III or IV
Research Technician required to work in the Nuclear Medicine section. The appointment will initially be for a fixed term of two years and due to the nature of the work, occasional evening and weekend working will be necessary in exchange for time off during the week. The Department currently offers a whole range of Nuclear Medicine services to the hospital. However, this post is specifically related to providing a Nuclear Medicine service to research projects, usually organised by departments in the School of Medicine. Two projects are now funded, although it is envisaged that others may occur in future. The first project is the investigation of a new tumour seeking agent labelled with In-111, the second is on the assessment of the effect of beta-lacking drugs on cardiac function using ECG gated radionuclide imaging. You should have experience of static and dynamic imaging work using a gamma camera and a computer and some knowledge of statistical analysis. Salary: Grade III £8306-£10 385 including London Weighting, Grade IV £7193-£9078 including London Weighting. For further details please contact Dr J. E. Agnew on 01-794 0500 (Ext 3214/5). Closing date 24 July, 1987. Hampstead Health Authority: An Equal Opportunity Employer.

THE UNIVERSITY OF LEEDS DEPARTMENT OF PHYSICS

POSTDOCTORAL RESEARCH FELLOW

Applications are invited for the above post available for a fixed period of up to three years from 1 October, 1987 for work on the fracture behaviour of oriented polymers involving the use of high pressure techniques. A good honours degree in physics, materials science or mechanical engineering and a PhD or research experience in mechanical testing of polymers are required.

Salary within the range £9305-£12 605 on RA Grade IA (£9305-£14 825) according to qualifications and relevant experience.

Informal enquiries may be made to Dr R. A. Duckett (Tel (0532) 431751 Ext 6221).

Application forms and further particulars may be obtained from the Registrar, the University, Leeds LS2 9JT, quoting reference No. 52/38. Closing date for applications 30 July, 1987.

IRON AGE RECONSTRUCTION PROJECT

Volunteers for July/August wanted. Free samples. Free advice. Castelli, Henly's, Mellie, Grymch, Dyfed. Tel (023979) 319.

ANALYTICAL CHEMIST

Horsham, West Sussex

Ciba-Geigy Pharmaceuticals is a major force in the manufacture and marketing of pharmaceutical preparations derived from international research and local development.

We are seeking to appoint an Analytical Chemist to join our Analytical Development Department. The successful applicant will be assisting in the analysing of a wide range of raw materials and dosage forms associated with the development of new products. The work involves a wide range of analytical techniques, particularly TLC, automated HPLC and GLC.

Applicants should possess a degree in Chemistry or a C-Chem (MRSC) qualification and preferably have relevant work experience.

In addition to a competitive salary, we offer a range of benefits which one would expect of a major international company, including a generous relocation package where appropriate.

For an application form and further details, please write to or telephone: Mrs. Sue Guyatt, Personnel Department, Ciba-Geigy Pharmaceuticals, Wimblehurst Road, Horsham, West Sussex RH12 4AB, Telephone: Horsham (0403) 50101, Ext. 3504.

CIBA-GEIGY

MICROBIOLOGY TECHNICIAN

£8220 to £9282 pa.

A Microbiology Technician, preferably with some experience in Recombinant DNA techniques and/or monoclonal antibody work, is required to service short courses in Molecular Biology and to have an input into some specialist undergraduate practicals and projects. After receiving essential training, the appointee will be expected to master a range of Recombinant DNA and Applied Immunological techniques.

The post is a new one, provided under the NAB Selective Initiatives Scheme, initially for one year with the strong probability of the appointment continuing for a further two years.

For further particulars and an application form, please write on a postcard to the Deputy Personnel Officer (Recruitment), City of London Polytechnic, 117-119 Houndsditch, London EC3A 7BU quoting reference number 87/89.

The Polytechnic is an equal opportunities employer

CityPoly

We are positively committed to a policy of equal opportunity for all. We look forward to receiving suitable applications from all sections of the community which will be considered on merit, regardless of sex, age, race, ethnic origin, marital status, responsibility for dependants, sexual orientation or disability.

UNIVERSITY OF GLASGOW Department of Electronics and Electrical Engineering

Research Appointment Power Electronics, Fast Tolerant, IAC Drives for Aerospace Applications
Applications are sought from suitably qualified candidates for a

RESEARCH ASSISTANTSHIP in the area of advanced power electronic drives technology, in a group headed by Prof Tim Miller. The initial appointment will be under a one year SERC grant. Further continuation of this work and related projects under the SPEED Programme (Scottish Power Electronics and Electric Drives Research Consortium) are likely to lead to an extended appointment and/or a second position.

This appointment will be on Grade 1A scale (academically-related staff) with commencing salary up to £12 035 pa. Applications including cv (three copies) with names and addresses of two referees, should be sent to Prof John Lamb, Department of Electronics and Electrical Engineering, The University of Glasgow, Glasgow G12 8QQ, not later than 31 July, 1987.

Further particulars will be provided on request.

PHD IN POWER ELECTRONICS

Applications are sought from suitably qualified candidates for Research Studentships leading to the Degree of PhD or MSc in several areas of power electronics control, automation and motion control systems engineering, including the design of AC and brushless DC motors.

Please contact Prof Tim Miller for further information. Tel 041 339-8855, Ext 4922 or 5231.

Cranfield

AERODYNAMICS RESEARCH

(WIND TURBINES)

A position has arisen in the team of engineers and scientists currently active in the field of wind energy. To investigate aspects of aerodynamics relating to vertical axis wind turbines. Current research concentrating on rotor blade surface pressure measurement and analysis, is being extended to examine alternative aerol profiles for lower cost rotors on full-sized machines. The project is collaborative, working alongside industrial/university research teams

The appointment is for two years in the first instance and the work would be suitable for consideration towards a higher degree. Candidates should have a good first degree in aeronautics, engineering or related disciplines.

Salary will be within the range £7100 - £7905 (£7532 - £8385 from March 1988)

Application forms are available from the Personnel Department, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL, telephone Bedford (0234) 750111 ext. 3343 quoting reference number 7058K.

School of Mechanical Engineering

Development Chemist

Wyeth Research (UK), part of a major international pharmaceutical company has an opening for an enthusiastic young chemist to join their Chemical Process Development team based at Havant.

This group has an important and growing role in supplying new drug substances for use in world-wide investigational studies. The work is challenging and varied, and will appeal to a chemist who wishes to make practical use of a real interest in organic synthesis.

The successful candidate will have a degree in Chemistry and some relevant experience will be an advantage. He or she must demonstrate the personal qualities needed to work effectively in a team environment.

In addition to a competitive salary, assistance will be given, where appropriate, with relocation expenses to this attractive part of the south coast.

To apply please telephone for an application form and further details, or send a comprehensive C.V. with details of your current salary to: Mr J.M. Atkinson, Senior Personnel Officer, Wyeth Research (UK), Wyeth Laboratories, New Lane, Havant, Hampshire. PO9 2NG. Telephone: Havant 483611 Ext. 2103.

Wyeth Research



Scottish Agricultural Colleges

The East of Scotland College of Agriculture

Soil Science Department

Research Assistant

Ref HGCA 1

Applications are invited for a Research Assistant in a new research project in the Soil Science Department, based at the Edinburgh School of Agriculture, West Mains Road, Edinburgh. The post is for a fixed term of three years.

The appointee will investigate by field and laboratory studies the nitrogen requirements for spring-sown matting barley and will have the opportunity to register for a higher degree. Candidates should have an honours degree in a relevant scientific subject and hold a full UK driving licence.

Commencing salary will be £8185 rising to £9305 per annum.

Further particulars and application forms may be obtained for the Secretary, The East of Scotland College of Agriculture, West Mains Road, Edinburgh EH9 3JG. Closing date for completed applications is 24 July, 1987. Please quote Ref HGCA 1 with all correspondence.

WEST LAMBETH HEALTH AUTHORITY

St Thomas's Hospital, London SE1 7EH

Medical Physics Technician II (Electronic and Electro Mechanical Engineering) £9758-£11 875 inc rail season ticket loan scheme

To work in the department's electronics laboratory and workshop. The work will involve the design, construction and repair of a wide range of equipment arising from the clinical and research work of the Radiotherapy, Medical Physics, Nuclear Medicine, X-ray and other departments. Although the post will be based in Medical Physics, some duties will be performed in other departments. Qualifications: O.N.C., H.N.C. or equivalent plus at least two years as MPT II or equivalent relevant technical experience.

For further information telephone the Medical Physics Department 01-928 9292 Ext 2374/2674.

For application form and job description, please write to the Personnel Department, or telephone our 24 hour Monday to Friday answering service on 01-261 1185 quoting job reference P/82 and appropriate job title.

Closing date will be 24th July, 1987.

An Equal Opportunity Employer



**Merck
diagnostics**

R & D LABORATORY SCIENTIST

Merck Diagnostics Limited is a young and rapidly expanding British company which develops, manufactures and markets diagnostic kits.

We are looking for a Laboratory Scientist to join our highly successful Research and Development team in its continuing programme developing immunoassay kits for the diagnosis of infectious diseases. The successful candidate will have responsibility for selected projects including collaboration with university departments and involvement with clinical trials. Applicants should be qualified at least to first degree level. Previous experience of immunoassay would be an advantage but is not essential.

Application form and further information from Mrs Valerie Corpes, Secretary to Technical Director, Merck Diagnostics Ltd, Merck House, Broadford Park, Guildford, Surrey GU4 8EW. Tel: Guildford (0483) 505255.

LEICESTERSHIRE HEALTH

AUTHORITY

Leicester General Hospital

PHARMACIST OR SCIENTIFIC OFFICER

A hot spot is available for a pharmacist or scientific officer providing radiopharmaceuticals for this busy radiodiagnosis unit in the Leicestershire Health Authority. Duties include assisting in the preparation and quality control of radiopharmaceuticals, blood labelling, and deputising in the absence of the staff pharmacist.

If you have the necessary energy to cope with the challenge, contact Gill Hartley, Staff Pharmacist, Radiopharmacy, Leicester Royal Infirmary, Tel Leicester (0533) 541414 Ext 5579. Application form, job description and details of salary available from the Leicester General Hospital, Grosvenor Road, Leicester. Tel Leicester (0533) 734493 (24 hour answering). Closing date 24 July.

INSTITUTE OF

HORTICULTURAL RESEARCH

Wellesbourne, Warwickshire

SHORT-TERM SCIENTIFIC OFFICER

A plant Pathologist Scientific Officer (Band 1) to work on a programme of research on cavity spot disease of carrots caused by *Pythium* spp.

The appointment is initially for one year only but with good prospects for extension.

Qualifications: First or Upper second class honours degree, or equivalent in scientific or related subject.

Salary in range of £6973-£9585. Non-contributory superannuation.

Apply for further details, quoting Ref I/W to Personnel Officer, Institute of Horticultural Research, Bradbourne House, East Malling, Maidstone, Kent ME19 6BJ.

The Institute of Horticultural Research is an equal opportunities employer.

THE LONDON HOSPITAL

MEDICAL COLLEGE

(University of London)

MOLECULAR BIOLOGY

POSTDOCTORAL

RESEARCH FELLOW

A three year position funded by the British Diabetics Association is available immediately to investigate the immunogenetics of diabetes mellitus. The successful candidate will join our established molecular biology group. Experience in the construction of genomic and cDNA libraries and/or DNA sequencing would be advantageous.

The salary is on the Research Fellow 1A scale, currently £9305 to £14 825 plus £1393 London allowance pa.

Further details may be obtained from Dr Graham A. Hitman Tel 01-275 7111. Applications including cv and the names of two referees should be sent to Dr G. A. Hitman, Medical Unit, The London Hospital, Whitechapel, London E1 1BB within three weeks of this advertisement.

SCHERING

PhD Biochemist & Chemistry Honours Graduate

Schering AG, West Germany, is a major force in the chemical industry worldwide. Within the UK our interests include pharmaceuticals, industrial chemicals, electroplating and chemicals for agriculture, and we employ over 2,000 people in a wide range of disciplines.

Biochemist Saffron Walden, Essex

Chesterford Park Research Station is the research and development centre for agrochemicals, and aims to discover and then develop herbicides, fungicides and animal health products for worldwide use.

Owing to expansion of the Chemical Synthesis Department, we now have an opportunity for a newly-qualified PhD Biochemist to join the team. You must have a strong chemical base and an appreciation of enzyme mechanisms, along with experience of various aspects of enzyme isolation, purification and assay. We are looking for an innovative thinker who enjoys teamwork and has project leadership potential. Previous applicants need not apply. Ref: CP1521.

Analyst Hauxton, Cambridge

The Analytical Development Department is seeking a Scientific Officer to optimise chemical processes and introduce new formulations to the product range. You will achieve this through the development, modification and application of analytical procedures for new compounds and formulations.

You should possess a good honours degree in chemistry or have an HNC and analytical experience. In either case, you should have an understanding of analytical chemistry and a practical approach to problem-solving. Ref: HQ/0056.

The competitive salaries are accompanied by a range of benefits including relocation assistance where appropriate. **Biochemist:** Please send full career and salary details to Jenny Lee, Personnel Department, Schering Agrochemicals Limited, Chesterford Park Research Station, Saffron Walden, Essex CB10 1XL. **Analyst:** Please send full career and salary details to Nicola Graver, Personnel Manager, Schering Agrochemicals Limited, Hauxton, Cambridge CB2 5HU.

Schering Agrochemicals Limited is a subsidiary of Schering AG, West Germany

UNIVERSITY OF HULL School of Chemistry INDUSTRIAL POSTDOCTORAL RESEARCH ASSISTANTSHIP IN ANALYTICAL CHEMISTRY/ BIOCHEMISTRY

Applications are invited from suitably qualified Analytical Chemists/Biochemists for a one year appointment sponsored by an international company involved in biotechnology. The successful applicant will undertake research on novel analytical procedures for the determination of hydrolytic enzymes using flow injection analysis. The post is available from September/October 1987 for a fixed period of one year.

Salary in the range £9305-£10 440 on the RA (IA) scale.

Application forms, to be returned by 7 August, 1987, are available from Dr P. J. Worfield, School of Chemistry, The University, Hull HU8 7RX (Tel 0482 465469), to whom informal enquiries may be addressed.

RIVERSIDE HEALTH AUTHORITY

Westminster/ Westminster Children's Hospital PHYSIOLOGICAL MEASUREMENT TECHNICIAN

Senior, Basic or Trainee Physiological Measurement Technician required. Activities will include making normal EEG and evoked potential recordings, prolonged EEG recordings (ambulatory and Video) and special evoked potential recordings on children and adults.

For a discussion about the post, please contact EEG, Dr R. M. Sherratt or Miss S. King on 01-828 9811, Ext 335/367.

Application form and job description available from the Unit Personnel Department, Queen Mary Nurses Home, 20 Page Street, London SW1P 4AP. Tel 01-400 0296 (24 hours). Please quote Ref M/07150.

Closing date: 23 July, 1987.

ROYAL POSTGRADUATE MEDICAL SCHOOL (University of London)

MRC Leukaemia Unit RESEARCH ASSISTANT

required to work on cytogenetics in leukaemia, particularly the study of chromosomes in B-CLL and the relationship to survival and evolution of the disease. The work will involve cell culture with various mitogens including EB virus, analysis of karyotypes, photography etc. There will be an opportunity to learn new techniques and to link with immunology and morphology of leukaemia cells.

Salary on range £5900-£9112 plus £1201 London Allowance depending on age and experience.

Application forms and further particulars may be obtained from the Personnel Office, Royal Postgraduate Medical School, 150 Ducane Road, London W12 0HS quoting Ref AP/MRC.

Closing date: 21 July, 1987.

PUBLIC HEALTH LABORATORY SERVICE BOARD

PHLS Centre for
Applied Microbiology & Research
Bacterial Metabolism Research
Laboratory

MICROBIOLOGIST

A graduate microbiologist is needed to work on the interaction between diet and the gut flora in its relation to colorectal cancer. The post is grant funded and initially is for 15 months.

The post is graded Basic Grade Microbiologist on a scale of C7452-C9996 ps.

National Health Service terms and conditions. Application forms from the Personnel Officer PHLS Centre for Applied Microbiology & Research, Porton Down, Salisbury, Wiltshire SP4 0JG.

Closing date 24 July, 1987.

Please quote post No 616 when applying.

THE UNIVERSITY OF LEEDS DEPARTMENT OF MECHANICAL ENGINEERING

LECTURESHIP

BIO-MEDICAL ENGINEERING (Bio-Tribology)

A lectureship (continuation of New Blood post) in Bio-Medical Engineering is available immediately. Candidates should preferably have qualifications, experience and special interests in the tribology (lubrication, friction and wear) of natural and total replacement synovial joints and bio-materials in order to enhance existing expertise and strengths in the department.

Salary on the scale for Lecturer Grade A (£28735-£31675) or Grade B (£24245-£28120) according to qualifications and relevant experience. Informal enquiries may be made to Professor D. Dowson (Tel 0532 431751, Ext 254).

Application forms and further particulars may be obtained from the Registrar, The University of Leeds, Leeds LS2 9JT, quoting Ref No. 09/52. Closing date for applications: 12 August 1987.

SCHERING
Agrochemicals

Graduate Scientist

Northern Centre, Leeds

The Northern Centre of the National Radiological Protection Board provides a wide range of services to all users of ionising and non-ionising radiation in the North of England. These include acting as Radiation Protection Adviser to a large number of establishments in pursuance of the Ionising Radiation Regulations, 1985, plus design studies, radiation surveys and general consultancy and a significant commitment to training courses. Additional work is carried out in support of the development of radiological protection techniques and the practical application of protection standards.

A Graduate Scientist, who must possess a clean driving licence, is required to join the existing team of experienced scientists. Minimum qualification is a good degree in an appropriate discipline; any radiation protection experience would be advantageous, as would some practical knowledge of computer techniques.

The appointment will be in the grade of Scientific Officer or Higher Scientific Officer, depending on age, qualifications and experience.

Salary range: Scientific Officer: £7485-£10 280pa.

Higher Scientific Officer: £9345-£12 590pa.

The board's Northern Centre is situated on the North Western edge of Leeds in the grounds of Cookridge Hospital.

Application forms can be obtained from Establishments and Personnel, National Radiological Protection Board, Chilton, Didcot, Oxon OX11 0RQ. Telephone: Abingdon (0235) 831600, Ext 553/548, quoting ref. PER/A244.

Completed application forms to be returned to National Radiological Protection Board, Northern Centre, Hospital Lane, Cookridge, Leeds LS16 6RW, no later than 27 July 1987.

National Radiological
Protection Board

Graduating in 1987 in Science?

Medical Representation could be for you

If you are graduating in 1987 in a life science and are wondering what to do with your hard earned qualification, you should consider medical sales.

Why? It offers

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- 4 Promotion possibilities to marketing and sales management

Salary of £5500 + car + benefits.
Sutcliffe Selection is renowned for the high quality of its graduate candidates, and has contacts with all the leading companies. To get your career organised, ring

0256 55955 (24 hrs)
or write to 46/48 Essex Road
Basingstoke RG21 1TB

Sutcliffe
Selection

PUBLIC HEALTH LABORATORY SERVICE BOARD

PHLS Centre for Applied
Microbiology & Research
Microbial Technology
Laboratory

GRADUATE SCIENTIST

To undertake research into the application of novel HPLC techniques to the purification of biopolymers (for example, proteins or oligonucleotides).

Applicants should have a first or second class degree in biochemistry or related biological subject, and possess a background knowledge of enzymology and protein chemistry. Experience in chromatographic techniques would be an advantage.

Appointment will be on the Basic Grade scale £6660-£9360 pa, under National Health Service terms and conditions.

Further information from Dr M. Scawen on Idmiston (0980) 610391.

The post is funded by a major international company. Application forms from the Personnel Officer, PHLS Centre for Applied Microbiology & Research, Porton Down, Salisbury, Wiltshire SP4 6JG, quoting Post No 0549.

Closing date: 24 July, 1987.

Do you have a contribution to make to Quality Assurance? SCIENTISTS

£8,500-£10,000

Are you an experienced scientist, feeling constrained and unappreciated — unable to use your abilities to the full? If so, ICI Plant Protection Division — world leaders in the agrochemical field can offer you a challenging change of direction in our growing Quality Assurance Team.

At our Jealott's Hill Research Station we invent and develop agricultural chemicals to help improve crop yields and reduce the food loss throughout the world to weeds, insects, plant diseases and vermin. In this dynamic research environment the small professional Quality Assurance Team is responsible for establishing the quality of pesticides safety studies in accordance with the principles of Good Laboratory Practice. This involves auditing protocols and reports against original data values, inspecting laboratory facilities, procedures and studies in progress.

The successful applicant will be educated to degree level in a biological or chemical discipline or have relevant laboratory experience in these fields. Familiarity with computers is essential as is the ability to communicate well both orally and in writing. Thorough on the job training will be given.

We offer a range of excellent benefits including pension scheme, staff restaurant and active sports and social club.

If this opportunity measures up to your ideas of career growth, write with full c.v., quoting ref. PID/QAU, to: Louise Gummer, Recruitment Administrator, ICI Plant Protection Division, Jealott's Hill Research Station, Bracknell, Berks RG12 6EY.

Closing date: 31st July 1987.

ICI is an equal opportunities employer.



Plant
Protection
Division

The world harvests the benefits



THE OPEN UNIVERSITY FACULTY OF SCIENCE RESEARCH ASSISTANT IN BIOLOGY

Applications are invited for the post of Research Assistant in the Biology Department of the Open University. The successful candidate will join a small group working on the physiology of fish pancreatic hormones, and the culture and transport of fish and mammalian B cells.

Applicants should have an honours degree in biology with substantial laboratory experience and the ability to work with a minimum of supervision.

The post is available immediately for a period of two years. Salary will be within the 18 scale for research and analogous staff: £1185-£11 015 ps.

Application forms and further particulars are available from Mrs B. Woodall (5202/2), Faculty of Science, Wimpsey II, The Open University, Walton Hall, Milton Keynes MK7 6AA, or telephone Milton Keynes (0908) 653993; there is a 24 hour answering service on 653868.

Closing date for applications: 27 July, 1987.



Southampton
THE
UNIVERSITY

Institute of Cryogenics

Applications are invited for a

LECTURESIP

in Cryogenics. Teaching duties include development of new short courses for industry and commerce in the rapidly expanding fields of cryogenic and refrigeration engineering.

Research and teaching experience in cryogenics or related engineering is desirable.

Salary in range up to £14 500 pa.

Further particulars may be obtained from Mr H. F. Watson, Staffing Department, University of Southampton, Highfield, Southampton, SO9 5NH, to whom applications (seven copies from UK candidates) should be sent with the names and addresses of three referees as soon as possible. Please quote reference number 267/HFW/JF.

Analytical Chemists

Smith Kline & French is one of the UK's leading research based pharmaceutical companies. We currently have openings for two Analytical Chemists in the following departments:

Analytical Development Department

The Department is responsible for the development and validation of analytical methods for compounds from research projects world-wide and new product support analysis. The department's data is an essential reference for Health Authority requirements. There is extensive use of chromatography and spectroscopy equipment and we're seeking someone with experience of instrumental techniques including H.P.L.C. and uv and ir spectroscopy. You'll probably be in your 20's and have a degree in Science, coupled with an MSc in Analytical Chemistry or at least 2 years' relevant experience in pharmaceutical analysis. (Ref AD)

Analytical Quality Control Department

The assessment of raw materials for our modern manufacturing plant is the overall function of this key department. The position represents an opportunity for an experienced analyst to carry out development work in our laboratory, updating methodology to maintain today's rigorous quality standards and meet the changing demands of our manufacturing division. The department also offers plenty of scope for capable individuals to move into management. A degree in Science or Tec V, coupled with a minimum of two years' experience in pharmaceutical analysis, that must have included some H.P.L.C. techniques, is essential. (Ref QC)

We offer a competitive salary plus an attractive range of benefits which include a discretionary annual bonus, BUPA, flexitime and a subsidised cafeteria.

Write with full C.V., quoting appropriate reference, to Catherine Warshaw, Personnel Officer, Smith Kline & French Laboratories Ltd., Mundells, Welwyn Garden City, Hertfordshire, AL7 1EY or telephone (0707) 325111 Ext 4649 for further details.

SK&F

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UNIVERSITY OF GLASGOW
UGC/Computer Board Teaching Initiative
RESEARCH PROGRAMMER
Applications are invited for a research programmer for a project on Molecular Graphics in Biotechnology and Molecular Pharmacology, coordinated by the Departments of Biochemistry and Chemistry. The project involves the use of a network of Gemini Challenger 68000-based microcomputers with Acorn Master 128 microcomputers as intelligent terminals and links to the University network. Applicants should have an interest in computer graphics. While not essential, experience in FORTRAN programming and 68000 assembler would be an advantage.
The post is available from 1 September 1987, or by arrangement, and is tenable for at least two years. Salary will be on the Administrative, Library and Computing Staff 1B scale starting at £8185 (£8675 from March 1988).
To apply for the post, please forward a cv and the names of two referees to Dr R. Eason, Biochemistry Department, University of Glasgow, Glasgow G12 8QQ.

UNIVERSITY OF SOUTHAMPTON
Cancer Research Campaign Medical Oncology Unit
RESEARCH ASSISTANT
Applications are invited for the above post to work on cloning and sequencing of genes for membrane glycoproteins. Applicants should have, or be about to obtain, an honours degree in Biochemistry, Biology or related area, and should preferably have studied molecular biology as part of their course. Any experience of recombinant DNA work would be an advantage.
The appointment will be for one year in the first instance at a salary of £8185 pa (increasing to £8675 pa on 1 March 1988). Applicants should be prepared to begin work as soon as possible, and on 1 September, 1987 at the latest.
Further details may be obtained by telephoning Dr T. Kenny or Dr D. Garrod on 0703-777222, Ext 4297/4315.
Applications giving the names of two referees should be sent to Dr T. Kenny, CRC Medical Oncology Unit, Centre Block, Southampton General Hospital, Southampton SO9 4XY, as soon as possible.

BLOOMSBURY HEALTH AUTHORITY St Peters Hospitals

BASIC GRADE/JUNIOR 'B' MLSO

Applications are invited for the basic grade/junior 'B' MLSO post working in a small research team within a routine diagnostic histopathology department. To assist with the preparation of specimens for electron microscope. One years experience required in routine histopathology. Some training preferred.

These hospitals are situated in the Covent Garden area and within easy access of services and amenities.

Salary: £3782-£5272—Junior 'B' MLSO.

£6008-£8477—Basic Grade.

Plus £1201 London Weighting.

Application forms and job descriptions from Personnel Department, St Philips Hospital, Sheffield Street, London WC2.

Closing date: 23 July, 1987.

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Contact John Spencer or forward a detailed CV in complete confidence quoting Ref. NS/79.



STS Recruitment, 85 High Street, Winchester, Hants SO23 9AP. Tel: (0962) 69478(24hrs).

Risk Management Consultants

As a specialist unit of The Bowring Group, itself part of the global organisation Marsh & McLennan Companies, Inc., Bowring Risk Management Ltd undertakes international risk management consultancy from its headquarters in the City.

In response to expanding demand for our services we are now recruiting graduate engineers or scientists to act as researchers, principally in the area of quantitative risk assessment.

Ideally, applicants should be between 22-27, previous industrial experience would be a distinct advantage, but more importantly, candidates should be able to display a high degree of numeracy and think creatively.

The positions are within a team of experienced consultants delivering a wide range of risk analysis and loss control services, both in the UK and overseas. The ability to communicate clearly with the client and to work effectively with other team members is essential.

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Cranfield

AERODYNAMICS RESEARCH

(WIND TURBINES)

A position has arisen in the team of engineers and scientists currently active in the field of wind energy, to investigate aspects of aerodynamics relating to vertical axis wind turbines. Current research concentrating on rotor blade surface pressure measurement and analysis, is being extended to examine alternative aerofoil profiles for lower cost rotors on full-sized machines. The project is collaborative, working alongside industrial/university research teams.

The appointment is for two years in the first instance and the work would be suitable for consideration towards a higher degree. Candidates should have a good first degree in aeronautics, engineering or related disciplines.

Salary will be within the range £7100 - £7905 (£7532 - £8365 from March 1988).

Application forms are available from the Personnel Department, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL, telephone Bedford (0234) 750111 ext. 3343 quoting reference number 7058K.

School of Mechanical Engineering

UNIVERSITY OF BRISTOL
Department of Ophthalmology

Postdoctoral Research Assistant

required to perform laboratory studies into ocular Onchocerciasis. Experience in parasitology and immunology will be required. Salary within range £9305-£11 460 pa within Range 1A.

Applications, stating the names of two referees, should be sent, by 24 July, 1987, to: Professor D. L. Easty, Department of Ophthalmology, Bristol Eye Hospital, Lower Maudlin Street, Bristol BS1 2LX.

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STUDENTSHIPS

UNIVERSITY OF CAMBRIDGE
Department of Materials Science and Metallurgy
Pembroke Street, Cambridge CB2 3QZ

CASE STUDENTSHIPS

Two CASE awards are available from 1 October 1987 for research into novel methods of producing metallic borides and the development of liquid metal ion sources.

Applications are invited from suitably qualified candidates in Chemistry, Materials Science and Metallurgy or Physics, to the Secretary to the Department of Materials Science and Metallurgy, Pembroke Street, Cambridge CB2 3QZ.

UNIVERSITY OF READING
Department of Physiology & Biochemistry
SERC RESEARCH STUDENTSHIP

A studentship is available for a three year study of the neuroendocrine regulation of luteinising hormone secretion from the anterior pituitary gland in the domestic fowl. Techniques will include the development of radioimmunoassays for neuro-peptides, the use of pituitary and neuronal cell cultures and the application of analytical procedures such as HPLC.

Applications including a cv and the names and addresses of two academic referees should be sent to Dr R. T. Gladwell, Department of Physiology & Biochemistry, PO Box 228, The University, Whiteknights, Reading RG6 2AJ.



LOUGHBOROUGH
UNIVERSITY
OF TECHNOLOGY

RESEARCH STUDENTSHIP

Applications are invited for a three year SERC CASE Studentship to study journal structures and user tasks when reading in both paper and electronic media. The Studentship is supported by the British Library Research and Development Department and the student will spend some time in British Library locations. Candidates should have a first degree in ergonomics or psychology. The student will be expected to register for a higher degree. For information telephone Dr C. McKnight (0509-261432); to apply please write to Professor B. Shackel, Department of Human Sciences, Loughborough, Leicestershire LE11 3TU.

UNIVERSITY OF EAST ANGLIA
School of Biological Sciences

SERC CASE STUDENTSHIP

Symbionts and the colour of aphids

Applications are invited from students who have obtained or expect to obtain at least a 2i degree in Biology or related subject for a CASE award in conjunction with Rotamated Experimental Station. The student will investigate the role of aphid symbionts in the production of the carotenoid pigments of aphids. The project will be supervised by Prof A. F. G. Dixon in collaboration with Drs H. D. Loxdale and A. Mudd.

Applications, including a cv and the names of two referees should be sent immediately to Prof A. F. G. Dixon, School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ.

UNIVERSITY OF NOTTINGHAM

Physical Biochemistry Laboratory

TWO INDUSTRIAL 'CASE' PHD STUDENTSHIPS FOR PHYSICAL SCIENTISTS/BIOCHEMISTS

1. SERC/CASE Award with Ciba-Geigy Pharmaceuticals, Horsham: Macromolecules as drug delivery systems.

2. AFRC/CASE Award with Unilever Research, Bedford: diffusion of proteins through biotechnologically relevant media (incl food matrices).

Both studentships offer the opportunity of a PhD and industrial experience with a leading company in either advanced drug delivery research or biotechnology. Both Ciba-Geigy and Unilever will supplement considerably the normal studentship grant.

Applicants should have a basic training in either Chemistry, Biochemistry, Physics or Biophysics and at least a 2i degree. Applications to Dr S. E. Harding, University of Nottingham, Dept Applied Biochemistry, Bonington LE12 5RD by 31 July. Enquiries Tel 0602 506011, Ext 8365.

UNIVERSITY OF LANCASTER

Departments of Biological Sciences and Chemistry

SERC PhD STUDENTSHIP

Applications are invited for a studentship on a SERC funded project to investigate sugar conformations in the pharmacologically active molecule heparin using very high-field NMR techniques.

Applicants should hold a good honours degree in Biochemistry, Chemistry or Biological Sciences. Application forms and further information can be obtained from Dr I. Nieduszynski, Department of Biological Sciences, University of Lancaster, Lancaster LA1 4YQ, Tel (0524) 65201, Ext. 4662.

Department of Biological Sciences

SERC/CASE STUDENTSHIP

Applications are invited for a CASE studentship in collaboration with ICI to investigate the transport and accumulation of triazole fungicides in wheat.

Applicants should hold a good honours degree in an appropriate biological subject. Application forms and further information can be obtained from Dr P. G. Ayres, at the above address, or Tel (0524) 65201, Ext. 4643.

U.W.I.S.T.

Welsh School of Pharmacy

SERC CASE Studentship, October 1987

Applications are invited from candidates with, or expecting to attain, a first or upper second class honours degree in Pharmacy or an appropriate chemical science degree for a research studentship in collaboration with Pfizer Central Research.

The project will be to investigate the stability of drug salt particles in inhalation aerosol propellants. Surface interactions between drug particles and surfactants will be investigated.

Enquiries should be made to Dr S. J. Farr, The Welsh School of Pharmacy, UWIST, PO Box 13, Cardiff CF1 3XF. Tel 0222 42586, Ext. 3460.

UNIVERSITY OF LEEDS

Department of Physics

SERC STUDENTSHIPS

Studentships are available for study leading to a PhD degree in the areas of high energy astrophysics and polymer physics. Applicants should hold at least an upper second class degree in physics or a related subject. Write or telephone as soon as possible to: Professor A. A. Watson, Department of Physics, University of Leeds, Leeds LS2 9JT. Tel 0532 431751, Ext. 6490.

PUBLIC HEALTH LABORATORY SERVICE BOARD

PHLS Centre for Applied Microbiology & Research

Microbial Technology Laboratory

MICROBIAL BIOPHYSICS/ SERC CASE PhD STUDENTSHIP

You will undertake collaborative study and training between Department of Microbiology, UC College Cardiff (Prof W. T. Coskey) and the above Centre to investigate the application of ultrasonic radiation forces in novel diagnostic microbial assays and the control of new laser microbial population characterisation techniques.

MICROBIAL BIOPHYSICS/ GENETICS/ SERC CASE PhD STUDENTSHIP

You will undertake collaborative study and training between Department of Microbiology, UCW Aberystwyth (Dr D. B. Kell) and the above Centre to investigate the physiology and biochemistry of microorganisms stabilised in water-immiscible solvents, particularly their exploitation in novel field induced DNA transfer and diagnostic tests.

Enquiries for these posts (Tel 0980 610391, Ext. 054) are invited from graduates holding (or expecting in June) at least a 111 honours degree or MSc in biological or physical sciences. Applications with full cv should be sent to: Dr J. Clarke, MTL PHLS CAMR, Porton Down, Salisbury, Wilts SP4 0JG. Closing date for both posts: 24 July, 1987.

UNIVERSITY OF READING

Department of Microbiology

POST GRADUATE STUDENTSHIP

A University of Reading Departmental Studentship to commence on 1 October, 1987 for a period of three years is available for a candidate wishing to study for a Higher Degree in this Department. The subject area concerns the molecular genetics of some aspect of yeast or filamentous fungi. The value of the studentship is presently £2850 p.a. plus the composition fee of £1730 p.a. which is paid by the University.

Applications should be addressed to Prof J. W. Almond, Department of Microbiology, University of Reading, London Road, Reading RG1 5AQ. Tel (0734 875234, Ext. 274) as soon as possible.

UNIVERSITY OF ST ANDREWS

RESEARCH STUDENTSHIP

PLANT MOLECULAR GENETICS

Applications are requested for a SERC PhD research studentship tenable for three years from 1 October, 1987. The research will be concerned with a molecular analysis of isozyme and restriction fragment length polymorphisms (RFLPs) in *Arabidopsis thaliana*.

Candidates should possess a first or upper second class honours degree in a Biological/Biochemical subject. Applications with a cv and the names of two referees should be sent to Dr R. Ingram and Dr J. Kinghorn, Plant Molecular Genetics Unit, Sir James Spence Building, University of St Andrews, St Andrews KY16 9TH

UNIVERSITY OF SOUTHAMPTON

Department of Chemistry

SERC STUDENTSHIPS

A number of SERC Studentships, including CASE awards, are still available from October, 1987 for research in all branches of Chemistry leading to the PhD degree. Strengths of the Department include: analytical chemistry, bioorganic and bioinorganic chemistry, computer modelling, coordination and organometallic chemistry, electrochemistry, kinetics, organic synthesis, photochemistry, polymer science including biopolymers, properties of liquid crystals, research into catalysts, solid state and surface chemistry, spectroscopy including magnetic resonance and lasers, structural chemistry.

Applicants should hold or expect to obtain a first or upper second class honours degree or its equivalent in Chemistry or a related subject. Applications, including the names of two referees and, if possible, a day time telephone number should be sent to The Postgraduate Admissions Tutor, Department of Chemistry, The University, Southampton SO9 5NH (Tel 0703 559122, Ext. 3811/3333) from whom further particulars may be obtained.

UNIVERSITY OF BIRMINGHAM

Department of Physics

CASE AWARD-NEUTRON SCATTERING RESEARCH ON POROUS MEDIA

Applications are invited for a Case studentship in the above area. The work involves studies of the structure of porous solids of practical importance using a matching absorbed liquid technique and of liquid diffusion through them using quasi-elastic neutron scattering. The results from both techniques will be compared with fractal and other theories. The project is in collaboration with Harwell Laboratory and involves some work at the Institut Laue-Langevin at Grenoble. An upper second or first class degree is essential.

For further information contact Dr D. K. Ross, Department of Physics, University of Birmingham, B15 2TT. Tel 021 472 1301 Ext. 3467.

UNIVERSITY OF ABERDEEN

MEDICAL RESEARCH STUDENTSHIPS

Applications are invited for PhD studentships for research with a range of disciplines, including Bacteriology, Biochemistry, Biostatistics and Cell Biology, Pathology, Physiology, Pharmacology and Surgery, within the Faculty of Medicine. The value of the studentships is similar to those of the Council. Further details from the Clerk to the Faculty of Medicine, University of Aberdeen, Regent Walk, Old Aberdeen AB9 9FK. Closing date for receipt of completed applications, 21 July.

UNIVERSITY COLLEGE LONDON

Department of Geological Sciences

SERC RESEARCH STUDENTSHIP

(CASE award with British Petroleum Research Centre, Sunbury-on-Thames)

Dilatancy, Acoustic Wave Velocity, and Fermeability in Rocks.

Cracking of crustal rocks by fluid and temperature enhances fluid storage and permeability, changes acoustic wave velocity and causes acoustic emission. Theoretical and experimental modelling of these processes, using crustal pressure/temperature conditions is important for exploration, reservoir engineering, and well-bore mechanics. This project will involve close cooperation with the reservoir technology group at BP Research Centre, and interaction with the International Ocean Drilling Programme. You will be a member of the very strong UCL team working in Rock and Mineral Physics, Rock and Sediment Deformation, and Physical Processes in the Earth's Crust, with Dr S. A. F. Murrell as supervisor. Your BP supervisor will be Dr P. J. Worthington, head of Formation Evaluation at BP and chairman of the Downhole Measurements panel of the Ocean Drilling Programme. The ODP uses a new ship, JOIDES RESOLUTION, and has well-logging facilities which are the most advanced in routine use in the world.

Applications are invited by 16 July from graduates with a First or Upper Second Class Honours Degree in a Physical or Biological subject (eg Earth Sciences or Physics) or Mathematics. Further details may be obtained from Dr Murrell, Dept of Geological Sciences, University College London, Gower Street, London WC1E 6BT or Tel 01-387-7050 Ext. 2360/7084 or 0707-324831.

UNIVERSITY OF SUSSEX

School of Mathematical and Physical Sciences

RESEARCH STUDENTSHIP IN SEMICONDUCTOR PHYSICS

Applications are invited for an SERC CASE research studentship for an experimental investigation, in collaboration with the General Electric Company Hirst Research Centre at Wembley, of the electronic properties of lattice defects in AlGaAs and GaAs semiconductor layers and of how such defects influence the characteristics and performance of AlGaAs/GaAs heterojunction bipolar transistors. It is expected that the project will include studies both of as-grown defects and of defects induced by irradiation with ions and electrons from the University of Sussex 3MV Van de Graaff Accelerator. The SERC maintenance grant for this studentship will be supplemented by £750 p.a. by GEC Hirst. Applicants should have a high class degree in physics, electronics or materials science.

Further details and application forms can be obtained from Dr D. J. Palmer, Physics Division, University of Sussex Brighton BN1 9QH (Tel 0273 678113).

UNIVERSITY OF LIVERPOOL

Department of Materials Science and Engineering

RESEARCH STUDENTSHIPS

Applications are invited from good honours (1st or 2nd) graduates in Metallurgy/Materials Science or related Physical Sciences for three year studentships tenable from 1 October, 1987 leading to the degree of PhD. SERC/CASE awards with industrial collaboration are available in the following areas:

(i) Influence of Solute Atoms on Replacement Collision Sequences in Metals. (UKAEA, Harwell Laboratory).

(ii) The Properties of Point Defect Clusters in HCP Metals (UKAEA, Harwell Laboratory).

(iii) Investigation of Fracture Propagation in Zircaloy. (CEGB).

(iv) Failure in Composite Design. (BP Research Centre).

(v) Structure of Heteroepitaxial Interfaces. (OEC).

(vi) Defect Nucleation in Heteroepitaxial Structures. (RSRE).

Quota awards, supplemented by additional industrial funds, are also available to support four of the following projects: Ferroelectric Domains in Ti-Diffused LiNbO₃, The Structure and Properties of Large Misch, III-V Epilayers, Computer Modelling of the Microstructure of Ceramics, Pultrusion of Composites, Electron Beam Lithography on a Nanometre Scale, Studies on the Solidification Behaviour of Aluminium Castings Alloys, Crack Propagation in a C/Mn Steel between 300 and 500°C, Structure Property Relationship in Liquid Polymers, Diffusion Through Surface Oxides, Ceramic Superconductors.

Applications, together with the names of two referees, should be received as soon as possible to Dr R. C. Pond, Department of Materials Science and Engineering, The University, PO Box 147, Liverpool L69 3BX.

UNIVERSITY OF BIRMINGHAM

Department of Physics

SERC STUDENTSHIP— HIGH TEMPERATURE SUPERCONDUCTORS

In view of the potential importance of the newly discovered high-temperature ceramic superconductor, a special SERC Quota Award has recently been released to work on the science and engineering of these materials. The project will be supervised by Dr C. E. Gough in the Department of Physics, but the work will be supported within the context of an interdisciplinary approach also involving the Departments of Metallurgy and Materials, Electronic and Electrical Engineering and Chemistry. An upper second or first class degree in Physics, Electronics or Electrical Engineering is essential.

For further details contact Dr C. E. Gough, Department of Physics, University of Birmingham, B15 2TT. Tel 021 472 1301 Ext 3265.

UNIVERSITY OF BRADFORD

SERC CASE STUDENTSHIP in collaboration with Pfizer Central Research

The funding for a SERC CASE Studentship leading to a PhD is currently available.

The project is entitled:

PHARMACEUTICS OF DRUG SALT SELECTION

and the work, supervised by Dr P. York, will be carried out in collaboration with Pfizer Central Research, under the direction of Dr J. I. Wells.

Applicants should possess or expect to obtain a first or upper second class honours degree in Pharmacy or Chemistry.

For further particulars, in the first instance contact Dr J. I. Wells, Pfizer Central Research, Ramsgate Road, Sandwich, Kent CT13 9NJ. Telephone (0304) 616177.

OXFORD POLYTECHNIC DEPARTMENT OF BIOLOGY

SHELL RESEARCH, SITTINGBOURNE SERC CASE STUDENTSHIP

Pharmacology of insect acetylcholine receptors Ref. 84
Studentship tenable for three years commencing in October, 1987 to investigate the pharmacology of acetylcholine receptors on insect neurones growing in culture. You will join a small research group directed by Dr D. J. Bee working on several aspects of the pharmacology of the insect nervous system. Candidates should hold or expect to gain a First or Upper Second Class Honours degree in an appropriate subject and experience in electrophysiology would be an advantage. Shell research provide an extra financial contribution to the student in addition to the normal SERC award.

Application forms and Further Particulars can be obtained from:

**The Staffing Office,
Oxford Polytechnic,
Gipsy Lane,
Headington, Oxford OX3 0BP**
Telephone 0865 819055/819056

Closing date for applications

24 July 1987

Re-advertisement. Previous applicants may re-apply

UNIVERSITY OF GLASGOW

Department of Microbiology SERC—CASE STUDENTSHIP

Applications are invited for a CASE studentship, tenable from 1 October 1987, to investigate interactions between *Candida albicans* and vaginal lactobacilli. The project is aimed at the development of novel antifungal agents and will be carried out in collaboration with Beecham Pharmaceuticals Research Division, Surrey.

Candidates should possess a First or Upper Second Class Honours Degree in Microbiology, Biochemistry or a related subject.

Applications, including a cv and the names and addresses of two referees, should be sent, as soon as possible to: Dr L. J. Douglas, Department of Microbiology, University of Glasgow, Garscube Estate, Bearsden, Glasgow G61 1QH.

UNIVERSITY OF LIVERPOOL

Department of Botany NERC RESEARCH STUDENTSHIP

Community richness and host-plant interactions in soil
This studentship tenable from October 1987 will investigate the assembly rules and role of phase-host interactions determining the species richness of bacterial communities in soil with emphasis on streptomycetes. It will be supervised by Drs A. M. Mortimer and S. T. Williams.

Candidates should hold or expect to gain a good Honours degree in an appropriate biological subject. Applications including the names of two referees should be sent to Dr A. M. Mortimer, Department of Botany, The University, PO Box 147, Liverpool L69 3BX as soon as possible.

Further details are available upon request Tel 051-709 6022, Ext 2392/61.

UNIVERSITY COLLEGE OF SWANSEA Research Studentship

Applications are invited from persons who have obtained or who are expected to obtain a first or upper second class honours degree in Materials Science, Physics, Chemistry or an Engineering discipline for a CASE Studentship to work on 'the micro-mechanics of Carbon Fibre' in close collaboration with Courtauld Research of Coventry. The successful applicant will study the effect of micro defects on the strength of carbon-fibre using new electron microscope techniques to reveal localised areas of high strain. The aim is to develop a self-consistent model for the micro-mechanics of such fibre and to help in the assessment and improvement of new fibres produced in the University and in industry.

Letters of application, to include a cv and the names and addresses of two referees, should be sent as soon as possible to Dr G. M. Jenkins, Department of Materials Engineering, University College of Swansea, Singleton Park, Swansea SA2 8PP.

Research Studentships

Applications are invited for two Research Studentships in the School of Biological Sciences. One is a SERC-CASE metabolism investigating the genetic control of foreign compound metabolism in microbial cultures with specific reference to the metabolism of mutagenic/carcinogenic chemicals, in collaboration with Shell Research Laboratories, Sittingbourne, Kent. The other is funded by the EEC, to investigate the mechanisms involved in the induction of chromosome changes in cultured cells and their relationship to tumour formation and genetic disease.

Applicants should have obtained a first or upper second class honours degree in a relevant biological or chemical science. The studentships will be for three years from 1 October, 1987 and both will be of the value of normal SERC studentships.

Further information may be obtained from Dr J. M. Parry, School of Biological Sciences, University College of Swansea, Singleton Park, Swansea SA2 8PP or Tel 0792-295385.

FELLOWSHIPS, GRANTS & SCHOLARSHIPS

School of Mechanical Engineering

A 3-year British Gas plc research scholarship is available for a student to study 'Flat plate heat exchangers: design optimisations for free and forced convection conditions' and so obtain a PhD degree.

The maintenance award is at normal SERC rates plus £1000 per annum, as well as additional allowances for experience and dependants.

Those interested should contact Professor Douglas Probert (Ref 1628) Applied Energy Group, School of Mechanical Engineering, Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL. Tel: Bedford (0234) 750111 Ext 2302.

Cranfield

UNIVERSITY OF ZIMBABWE

Applications are invited for the following posts:

RESEARCH FELLOWSHIPS/ SENIOR RESEARCH FELLOWSHIPS: UNIVERSITY LAKE KARIBA RESEARCH STATION (3 Posts)

Applications are invited for research fellowships in any of the following:

1. **Fish pathology:** The appointee will be required to undertake research in fish pathology in aquaculture fisheries and capture fisheries to provide basic information on pathogens of economic importance and, where possible, their control.
2. **Fisheries stock assessment:** The appointee will be required to evaluate current fish stock assessment methods and to make such recommendations as would contribute to improvements in stock assessment methodology.
3. **Post-harvest fish management:** The appointee will be required to undertake an evaluation of post-harvest product management in the Lake Kariba fisheries and to investigate the possible basis for a cottage industry in fish processing.
4. **Resource/land use planning:** The appointee will be required to undertake a critical evaluation of current resource/land use strategies in the Lake Kariba environs and their possible long-term outcome and to make such recommendations on land use strategies that would be ecologically sustainable on long-term perspectives.
5. **Sediment studies:** The management of Lake Kariba was planned in an ameliorating ecological climate. Increased populations and the extermination of the tsetse fly, *Glossina morsitans*, is rapidly leading to a change in the ecological environment of the lake. The successful candidate will be required to provide basic data on sediment rates in Lake Kariba and their possible impact on the ecology and management of the lake.
6. **Primary production:** Lake Kariba supports an expanding fishery industry, primarily based on the introduced planktivore, *Limnithys niloticus*. However the ecological base of this fishery is of primary production is little understood. The appointee will be required to assess primary production in the lake in support of other limnological studies being undertaken.
7. **Agriculture:** The appointee will be expected to study existing agricultural enterprises in the Lake Kariba environs, prospects and sustainability.
8. **Health:** The appointee will be required to undertake studies on the biology and epidemiology of schistosomiasis on Lake Kariba with the object of defining the extent of the schistosomiasis problem on the lake, particularly among the fishing communities, and to develop possible control strategies.
9. The appointee will be required to participate in a research co-operation with Cairo University. The project consists of ecosystem characterisation using soil fauna. The appointee must be a Zimbabwean national.

Candidates for these fellowships must normally hold a PhD in appropriate sciences, but holders of other good degrees will be considered.

TEACHING ASSISTANTSHIP: DEPARTMENT OF GEOLOGY

The post requires a good "all rounder", who will be expected to teach and assist with courses taught to Civil, Mining, Metallurgical Engineering students and Soil Science students. Preference will be given to candidates with strengths in crystallography, mineralogy and petrology. Minimum qualification is an upper second pass, BSc honours geology degree.

Salary Scales: (Medical—including professional supplement) Associate Professor Z\$34 884-Z\$35 640; Professor Z\$35 988 (fixed). (Non-Medical) Lecturer Z\$18 216-Z\$26 832; Senior Lecturer Z\$27 732-Z\$30 360; Associate Professor Z\$31 284-Z\$32 640; Research Fellow Grade II Z\$14 304-Z\$16 632; Research Fellow Grade I Z\$17 236-Z\$19 464; Senior Research Fellow Z\$22 536-Z\$26 544; Teaching Assistant Z\$10 992-Z\$15 480. Appointment on the scales according to qualifications and experience.

CONDITIONS OF SERVICE: Both permanent and short-term contracts are offered. Persons who are not Zimbabwean citizens may be appointed only on a short-term contract basis for an initial period of two years. Short-term contracts may be extended.

Six copies of applications, giving full personal particulars, which should include full name, place and date of birth, qualifications, employment and experience, present salary, date of availability, telephone number and names and addresses of three referees should be addressed to the Director, Appointments and Personnel, University of Zimbabwe, PO Box MP167, Mount Pleasant, Harare, Zimbabwe (telex: 4-152 ZW). Applicants in the UK should also send an additional copy of their application to the Secretary General, Association of Commonwealth Universities (Appsu), 36 Gordon Square, London WC1H 0PF, from whom further particulars are available. Closing date for receipt of applications is 21 July, 1987.

POSTDOCTORAL RESEARCH FELLOWSHIP

Medical Oncology Unit, Edinburgh

Applications are invited for a three year postdoctoral research fellow to continue work on a project to investigate cytotoxic drug interaction with interferons and related substances under the supervision of Professor Smyth.

PhD in cell biology, experimental therapeutics, immunology or virology.

Salary range: £11 000-£14 000.

Full cv and names and addresses of three referees should be sent to Ms S. M. Hurley, Personnel Officer, Imperial Cancer Research Fund, 44 Lincoln's Inn Fields, London WC2A 3PX, quoting Ref. 128/R.

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ARIADNE

Great place for a high-tech shoe shiner, they said, and what happens? Not one customer.

HAVING had some trouble with the delivery of my letters in the past few months, I eventually found the red mist descending and wrote a complaining letter to the Post Office. Several weeks later, I got a reply, headed "Royal Mail Letters, A part of The Post Office".

It said it was sorry. It also said that the Post Office's aim is "to deliver 90 per cent of first class letters on the day following the day of despatch" and that a nationwide monitoring had shown that "we are very close to this standard". Such is the power of frank, honest, polite and explanatory prose that I was mollified, until, some time afterwards, I realised that to have an aim of 90 per cent efficiency is hardly the most noteworthy of ambitions.

Anyone who said that his dream as a climber was to get nine-tenths of the way up Everest could expect, in Whitelaw's immortal phrase, to stir up apathy, and an airline's ambition to succeed in flying nine out of ten of its machines across the Atlantic might be greeted with something more. It seems to me to be a shade complacent to congratulate yourself on nearly reaching the standard of not bad.

An alternative way of looking at it is that the Post Office has set itself the aim of failing to do what it is paid for by first class postage with 10 per cent of the letters it handles. By heaven, crumbs and golly, it is within sight of that point. That is, if you have faith in its nationwide monitoring results, without knowing how the monitoring is carried out.

I recommend an aim of 100 per cent next-day delivery of first class mail. Even though we all know that is impossible, why aim at less? If the Post Office reaches the 90 per cent, will it set off fireworks and have the conduits of the country running with claret in celebration of being fairly good? □

LORD CURZON happened to be passing his butler's pantry when the door was open. Inside, the butler was carrying out a strange task. He was rolling up table napkins and inserting them into metal rings. Curzon, puzzled, asked the butler what he was doing. The butler replied that it was a common custom to use a napkin and then have it stored in the ring ready for the next meal and that this was the custom also in the servants' hall. "Good God!" cried Curzon.

Nowadays, damask or linen table napkins are seldom seen and most people—or, at least, most of those I know—make do with paper ones, though I think the fashionable word for them, once again, is "serviettes".

Certainly, in detective stories, and perhaps in real life, great consequences hang on the lap. Because women are used to wearing skirts, they have commodious



laps and are alleged involuntarily to part the knees to catch anything tossed to them. Men are alleged to do the opposite, pressing their knees together. Bulldog Drummond, I remember, caught out the villain, Carl Petersen, this way as Petersen was in drag while making an escape. The point is that serviettes fall off trousered knees because of the paucity of lap, but remain on skirted ones.

The social importance of this is easy to see at any dinner party and is perhaps more spectacular at a formal one. Every now and then, a man will disappear under the table and reappear, like a diving duck, red-faced, but with the napkin retrieved. At a long table, it is possible to make bets on who will dodge downwards next.

Some of the dodging may be accompanied by hurried movements from the ladies and even a choked-off scream may be heard as some man in search of his serviette is forced to go grovelling among the legs under the tablecloth. Such scenes can ruin friendships and put severe strain on marriages.

There is a solution and I am surprised that it has not been applied before. Technology has given us glues that leave no trace. They are used on identification labels, for instance, and do no harm to labels when the tags are torn off after the event that necessitated wearing them. A strip of this adhesive along one edge of a serviette would keep every man upright and spotless in every sense of the word. □

THE SILLY SEASON is shaping up nicely, as I thought it might after a vintage Easter for observers.

There has been a flood of reports of people being abducted by the crews of flying saucers, most of the "abductees", as the Americans call them, being treated as biological specimens and having small areas of the skin of their legs removed. They have the scars to reveal as evidence. Moreover, under hypnosis, some of those kidnapped have recalled their experiences at the hands of their bulging-eyed captors and you can't say fairer than that.

In Siberia a triton, a kind of salamander, has come back to life after spending several

thousand years hibernating in the permafrost layer. It was found by gold-miners and when put down in the light of day, it moved, crawling around and turning its head. It, too, had bulging eyes, but it did not last long, apparently. The USSR was also the scene of the sighting by a British air crew of an object with twinkling lights flying straight towards them. It was not an aircraft, they say. The "mystery" object (whatever happened to adjectives?) was most probably a satellite re-entering the atmosphere, but that explanation will not satisfy the flying saucer fans.

Lastly, statues of the Virgin Mary are on the move again, but there is some discrimination by the moving force. A report from Ireland said that statues 18 inches high had been seen to move, but not smaller ones.

All this is much better than the old stories of the Loch Ness monster and flying eggs on the pavement in Fleet Street. □

HYDROELECTRIC power generation is a way of trapping some of the energy released by rain and snowfall running off high mountains. Daedalus now proposes a more radical scheme: trapping energy from the descent of the mountains themselves. There is a vast amount of energy locked in the world's heights. America's electricity demand could be met for a thousand years by allowing a mere 1 per cent of the Rockies to descend into the Pacific over that time.

"Geoelectric power" will need some technical development. The obvious approach is to adapt conventional quarrying methods, and to allow the spoil to descend into the sea by a bucket-ropeway whose pulleys, driven by their descending burden, turn the generators.

A more elegant method would employ the snowfall on the mountain to create a dense slurry of rock and water to descend by pipeline. Turbines driven by such a gritty medium would soon disintegrate; Daedalus is designing a pipeline in the form of an Archimedes' screw which, turning on its axis, will extract the energy of descent neatly and efficiently.

This bold scheme will be most attractive in regions where high mountains border an ocean in which useful lowlands could be created by dumping the accumulating spoil. Daedalus will point out to enraged ecologists that he is merely imitating a natural process. The world's uplands are always being eroded, and carried as river silt down to a level where they can create new land as alluvial mud and river delta.

Furthermore, this artificial erosion won't even destroy the mountains. A mountain, says Daedalus, isn't just a heap: it is in hydrostatic equilibrium. Like an iceberg, it is floating on the deeper layers, or being forced aloft by tectonic pressures. Lighten it by cutting the top off, and the rest will float higher to re-establish the original height.

Daedalus's scheme is not tapping a wasting asset; it is powered by the same basic tectonic forces that drive the drifting continents. Friends of the Earth should feel a deep oneness with electricity generated in such a primal manner. □

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